US009060374B2

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Okabe et al.

(10) **Patent No.: US 9,060,374 B2**
(45) **Date of Patent: *Jun. 16, 2015**

(54) **COMMUNICATION METHOD, MOBILE NETWORK SYSTEM AND DEVICE**

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(73) Assignee: **NEC CORPORATION**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(22) Filed: **Mar. 15, 2012**

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US 2012/0184275 A1 Jul. 19, 2012

(30) **Foreign Application Priority Data**

Apr. 27, 2010 (JP) 2010-102166

(51) **Int. Cl.**

H04W 4/00	(2009.01)
H04W 76/06	(2009.01)
H04W 76/04	(2009.01)
H04W 8/06	(2009.01)
H04W 24/04	(2009.01)
H04W 60/04	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 76/068*** (2013.01); ***H04W 76/045*** (2013.01); ***H04W 8/065*** (2013.01); *H04W 24/04* (2013.01); *H04W 60/04* (2013.01)

(58) **Field of Classification Search**

CPC H04W 8/065; H04W 8/08; H04W 8/12; H04W 88/16; H04W 76/045; H04W 76/068

USPC 455/435.1; 370/328, 244

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0074994	A1	3/2008	Jen
2008/0076404	A1	3/2008	Jen
2008/0076405	A1	3/2008	Jen
2009/0239526	A1	9/2009	Zhao et al.
2009/0325634	A1	12/2009	Bienas et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN	101472256	A	7/2009
EP	2 346 219	A1	7/2011

(Continued)

OTHER PUBLICATIONS

Alcatel-Lucent, "The LTE Network Architecture—A comprehensive tutorial", 2009, Strategic White Paper.*

(Continued)

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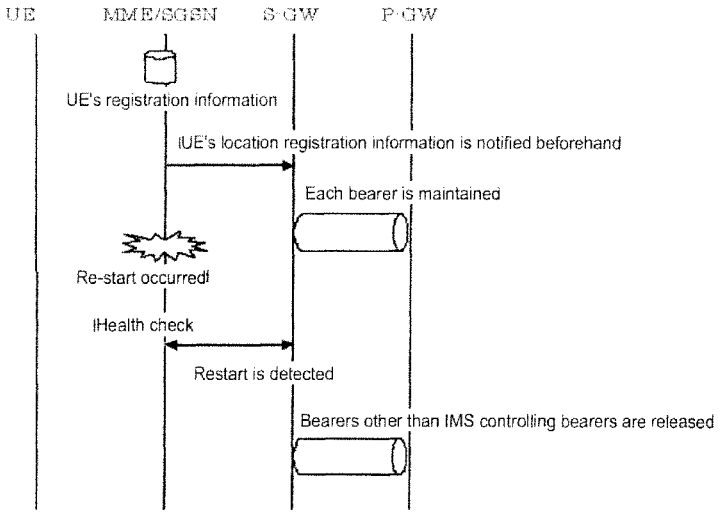
(74) *Attorney, Agent, or Firm* — McGinn IP Law Group, PLLC

(57) **ABSTRACT**

A mobile terminal (UE) used in a mobile communication network that includes a mobility management entity (MME) and a serving gateway (S-GW), receives paging from the mobile communication network, upon an arrival of an incoming call destined for the mobile terminal at the mobile communication network, in which if the mobility management entity has restarted, the serving gateway maintains a specific S5/S8 bearer for a preset time period prescribed by a timer, and deletes the specific S5/S8 bearer on timeout of the timer, and in response to the paging, re-attaches to the mobile communication network.

17 Claims, 24 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0056147	A1	3/2010	Sun et al.	
2010/0080116	A1	4/2010	Agashe et al.	
2010/0142467	A1	6/2010	Tiirola et al.	
2010/0165937	A1	7/2010	Yi et al.	
2010/0208596	A1*	8/2010	Jin	370/242
2010/0220643	A1	9/2010	Qi et al.	
2010/0260115	A1	10/2010	Frederiksen et al.	
2011/0019637	A1	1/2011	Ojala et al.	
2011/0075675	A1*	3/2011	Koodli et al.	370/401
2011/0138033	A1	6/2011	Yang et al.	
2011/0194406	A1	8/2011	Ye et al.	
2012/0094627	A1	4/2012	Suh et al.	
2012/0172066	A1*	7/2012	Okabe et al.	455/458
2012/0178479	A1*	7/2012	Okabe et al.	455/458
2012/0202496	A1*	8/2012	Okabe et al.	455/435.1
2012/0202532	A1*	8/2012	Okabe et al.	455/458
2012/0214519	A1*	8/2012	Okabe et al.	455/458

FOREIGN PATENT DOCUMENTS

JP	2008-079313	A	4/2008
JP	2010-45429	A	2/2010
WO	WO 03/039186	A1	5/2003
WO	WO 03/041435	A1	5/2003
WO	WO 2009/121255	A1	10/2009
WO	WO 2009/121255	A1	10/2009
WO	WO 2010/019364	A1	2/2010
WO	WO 2010/043094	A1	4/2010

OTHER PUBLICATIONS

Pierre Lescuyer, Thierry Lucidarme, The LTE and SAE Evolution of 3G UMTS, Feb. 11, 2008, John Wiley & Sons.*

3GPP TR 23.857, Technical Specification Group Core Network and Terminals; Study of EPC Nodes Restoration; (Release 10), Mobile Competence Centre; 650, Route Des Lucioles; F-06921 Sophia-Antipolis Cedex; France, No. V1.2.0, Mar. 7, 2011, pp. 1-31, XP050476278.

NEC: "EPC node failure", 3GPP Draft; C4-101116, Mobile Competence Centre; 650, Route Des Lucioles; F-06921 Sophia-Antipolis Cedex; France, vol. CT WG4, No. Kyoto; 20100510, May 17, 2010, XP050411725.

3GPP TS 23.007, 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Restoration procedures (Release 9), Mobile Competence Centre; 650, Route Des Lucioles; F-06921 Sophia-Antipolis Cedex; France, No. V9.3.0, Apr. 6, 2010, pp. 1-39, XP050402405.

CATT: "Clarifying the bearers to be deactivated on the S5/S8 interface", 3GPP Draft; C4-100955 (Was 100924 CR0544), Mobile Competence Centre; 650, Route Des Lucioles; F-06921 Sophia-Antipolis Cedex; France, vol. CT WG4, No. San Francisco, US; 20100222, Mar. 2, 2010; XP050411498.

Ericsson: Discussion paper on the handling of hanging PDN connections/bearers Specs: 3GPP TS 23.007, 3GPP TS 29.274, 3GPP Draft; C4-100405, Mobile Competence Centre; 650, Route Des Lucioles; F-06921 Sophia-Antipolis Cedex; France, vol. CT WG4, No. San Francisco, US; 20100222, Mar. 2, 2010, XP050411046.

3GPP: "3GPP TS 23.401; Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (Release 9)", 3GPP Standard; Mobile Competence Centre; 650, Route Des Lucioles; F-06921 Sophia-Antipolis Cedex; France, No. V9.4.0, Mar. 25, 2010, pp. 1-258, XP050402066.

Extended European Search Report dated Jun. 5, 2012, filed in U.S. Appl. No. 13/421,575.

Extended European Search Report dated Jun. 1, 2012, filed in U.S. Appl. No. 13/421,602.

Extended European Search Report dated Jun. 1, 2012, filed in U.S. Appl. No. 13/421,621.

Extended European Search Report dated Jun. 1, 2012, filed in U.S. Appl. No. 13/421,628.

Extended European Search Report dated Jun. 4, 2012, filed in U.S. Appl. No. 13/421,641.

Ericsson: "Discussion paper on the handling of hanging PDN connections/bearers Specs: 3GPP TS 23.007, 3GPP TS 29.274", 3GPP Draft; C4-100405, Mobile Competence Centre; 650, Route Des Lucioles; F-06921 Sophia-Antipolis Cedex; France, vol. CT WG4, No. San Francisco, US; 20100222, Mar. 2, 2010, XP050411046.

Extended European Search Report dated Jun. 1, 2012.

3GPP TS 23.203. V9.4.0.,3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Policy and charging control architecture (Release 9), Mar. 2010, 11.1 Restart of the SGSN.

3GPP TS 23.272 V9.3.0, 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Circuit Switched (CS) fallback in Evolved Packet System (EPS); Stage 2 (Release 9), Mar. 2010, 11.1 Restart of the SGSN.

3GPP TS 23.007 V9.3.0, 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Restoration procedures (Release 9), Mar. 2010, 11.1 Restart of the SGSN.

International Search Report in PCT/JP2011/060215 dated Jul. 5, 2011 (English Translation Thereof).

Japanese Office Action dated Feb. 3, 2012, with partial English translation.

Ericsson, Cleanup of hanging PDN connections/bearers, C4-100406, 3GPP, Feb. 26, 2010, URL, http://www.3gpp.org/ftp/tsg_ct/WG4_protocollars_ex-CN4/, TSGCT4_48_San _Francisco/docs/C4-100406.zip.

Ericsson: "Cleanup of hanging PDN connections/bearers", 3GPP Draft; C4-100406_WAS093573_23007_Cleanup_Hanging_PDN_Connections_DBR_DSR_REL9, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre; 650, Route Des Lucioles; F-06921 Sophia-Antipolis Cedex; France, vol. CT WG4, No. San Francisco, US; 20100222, Mar. 2, 2010, XP050411047.

Extended European Search Report dated Jul. 19, 2012 filed in U.S. Appl. No. 13/381,746.

US Office Action dated Jan. 8, 2013 in co-pending related U.S. Appl. No. 13/421,621.

US Office Action dated Dec. 4, 2012 in co-pending related U.S. Appl. No. 13/421,641.

US Office Action dated Jan. 11, 2013 in co-pending related U.S. Appl. No. 13/421,628.

3GPP TS 23.007 V10.0.0 (Jun. 2010): 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Restoration procedures (Release 10).

US Office Action dated Mar. 7, 2013 in co-pending related U.S. Appl. No. 13/421,575.

US Office Action dated Mar. 7, 2013 in co-pending related U.S. Appl. No. 13/421,602.

3GPP TS 23.007 V9.3.0 (Mar. 2010) 3d Generation Partnership Project; technical specification group Core Network and Terminals; Restoration Procedures (Release 9).

US Notice of Allowance and Fee(s) Due dated Apr. 15, 2013 in co-pending related U.S. Appl. No. 13/421,628.

US Office Action dated Jan. 3, 2013 in co-pending related U.S. Appl. No. 13/381,746.

US Office Action dated Jun. 5, 2013 in co-pending related U.S. Appl. No. 13/421,641.

US Office Action dated Jun. 10, 2013 in co-pending related U.S. Appl. No. 13/381,746.

US Office Action dated Jan. 24, 2014 in co-pending related U.S. Appl. No. 13/421,575.

US Notice of Allowance and Fee(s) Due dated Jul. 5, 2013 in co-pending related U.S. Appl. No. 13/421,575.

US Office Action dated Jul. 24, 2013 in co-pending related U.S. Appl. No. 13/421,621.

Chinese Office Action dated Oct. 14, 2014 with an English Translation thereof.

Japanese Office Action dated Feb. 25, 2015 with partial English Translation.

United States Office Action dated Apr. 7, 2015 in U.S. Appl. No. 13/381,746.

* cited by examiner

FIG. 1

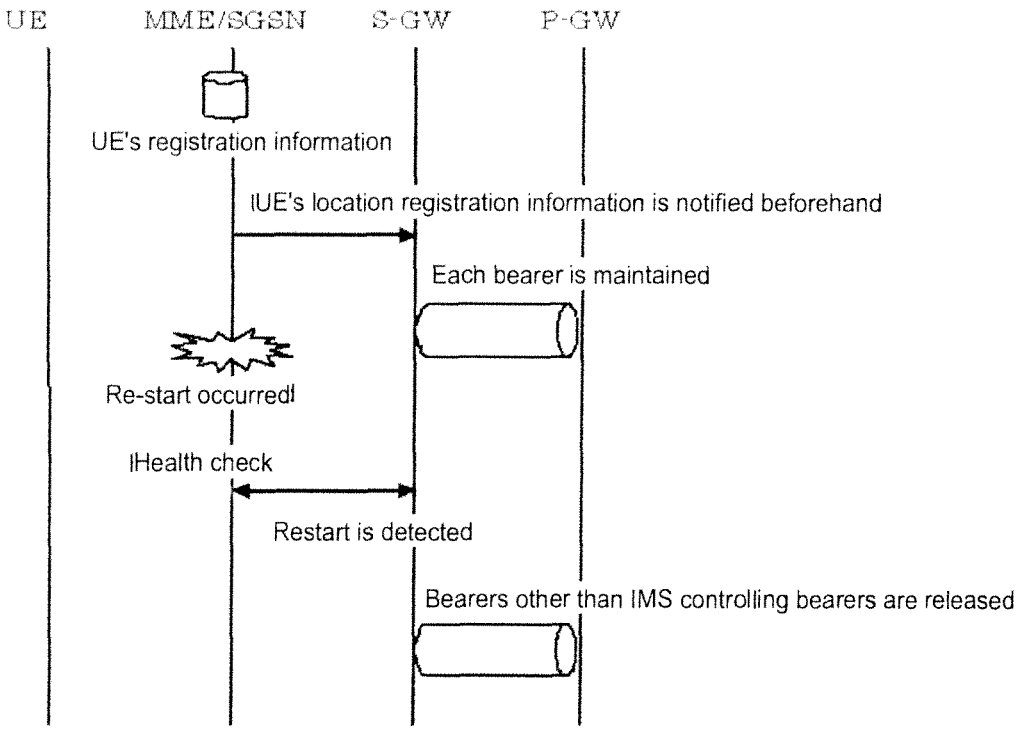

UE
MME/SGSN
S-GW
P-GW
UE's registration information
UE's location registration information is notified beforehand
Each bearer is maintained
Re-start occurred
Health check
Restart is detected
Bearers other than IMS controlling bearers are released

FIG. 2

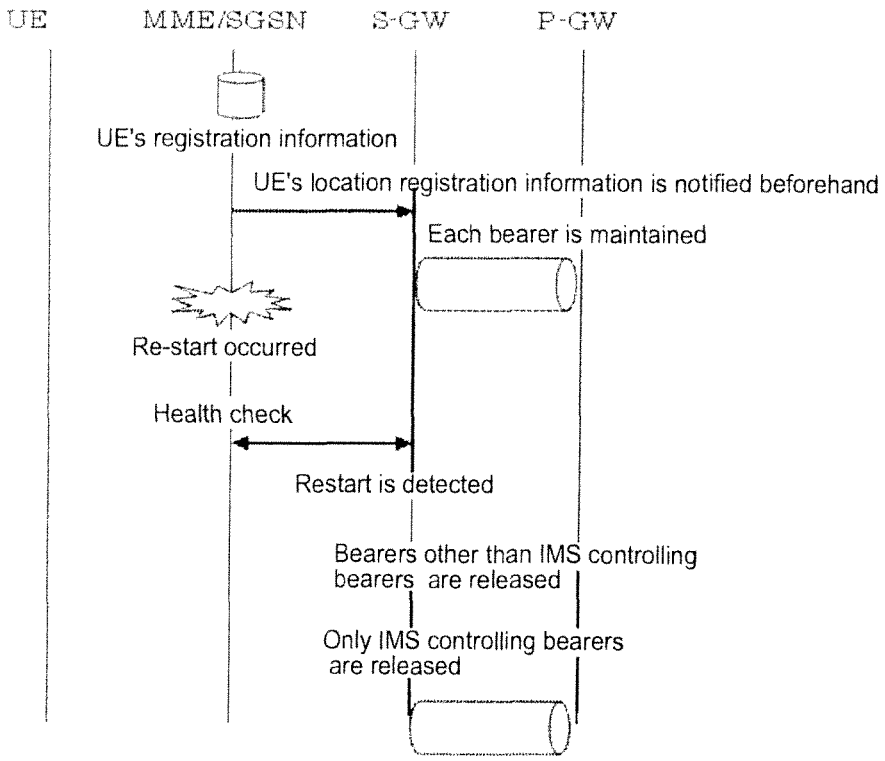

UE
MME/SGSN
S-GW
P-GW
UE's registration information
UE's location registration information is notified beforehand
Each bearer is maintained
Re-start occurred
Health check
Restart is detected
Bearers other than IMS controlling bearers are released
Only IMS controlling bearers are released

FIG. 3

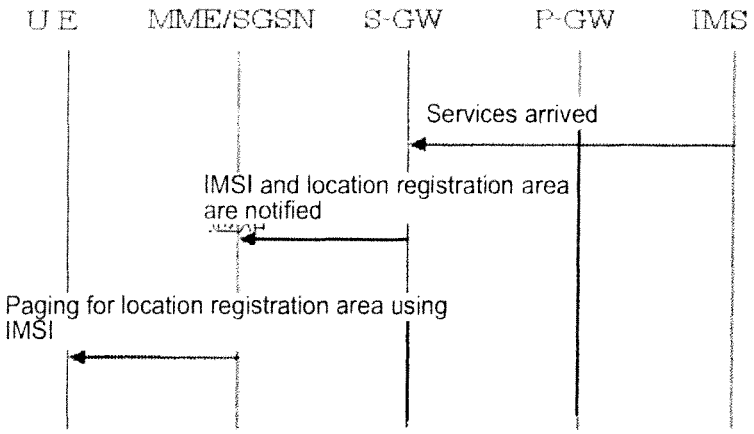

U E
MME/SGSN
S-GW
P-GW
IMS
Services arrived
IMSI and location registration area are notified
Paging for location registration area using IMSI

FIG. 4

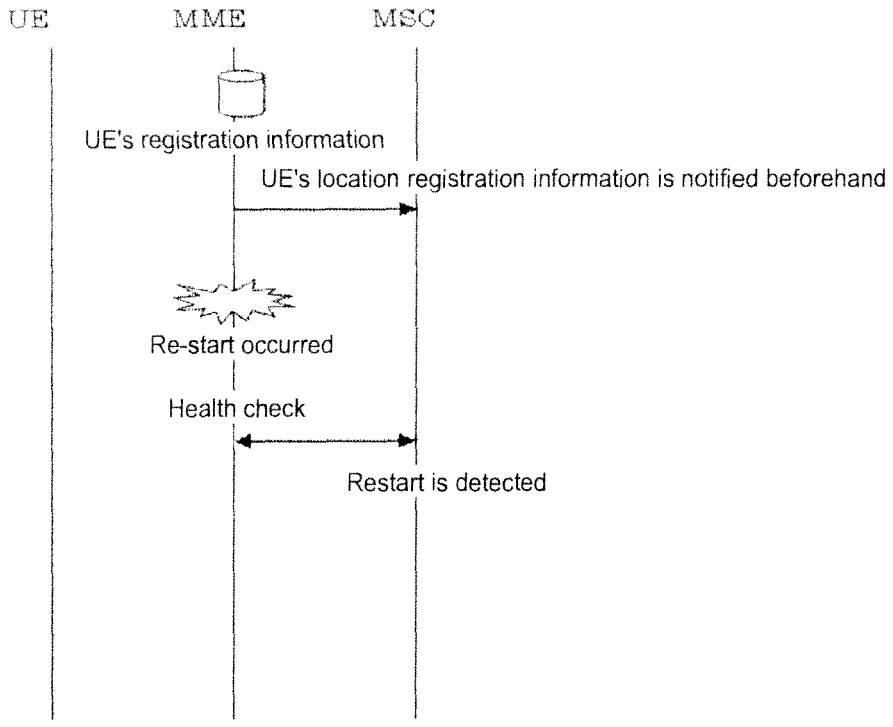

UE
MME
MSC
UE's registration information
UE's location registration information is notified beforehand
Re-start occurred
Health check
Restart is detected

FIG. 5

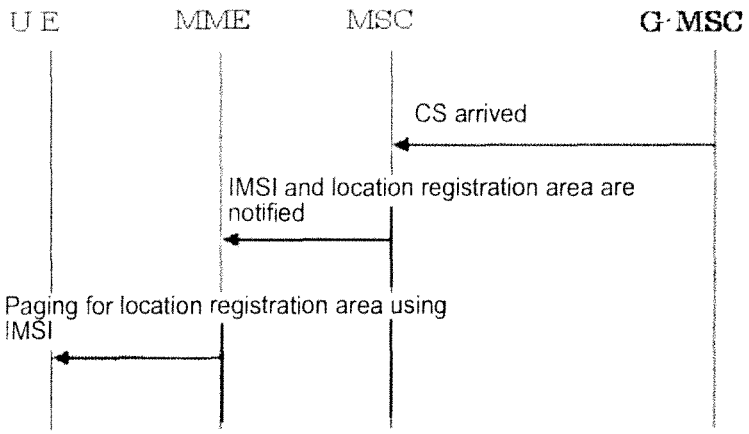

U E
MME
MSC
G-MSC
CS arrived
IMSI and location registration area are notified
Paging for location registration area using IMSI

FIG. 6

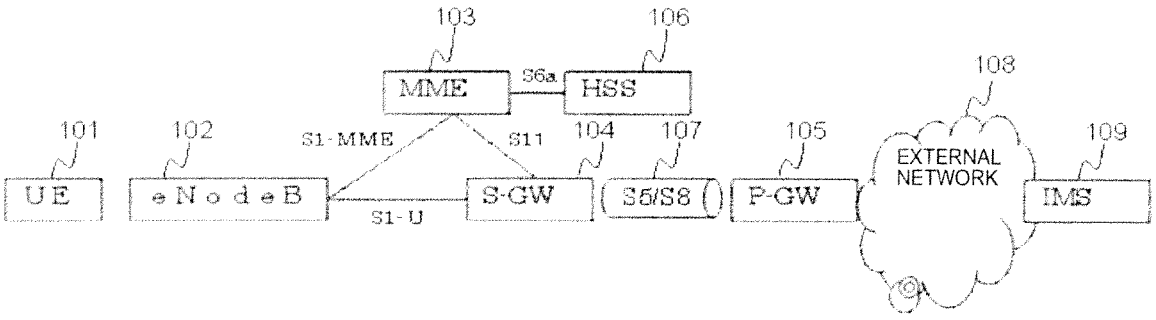

103
106
MME
S6a
HSS
108
101
102
S1-MME
S11
104
107
105
EXTERNAL NETWORK
109
UE
eNodeB
S-GW
S5/S8
P-GW
IMS
S1-U

FIG. 7

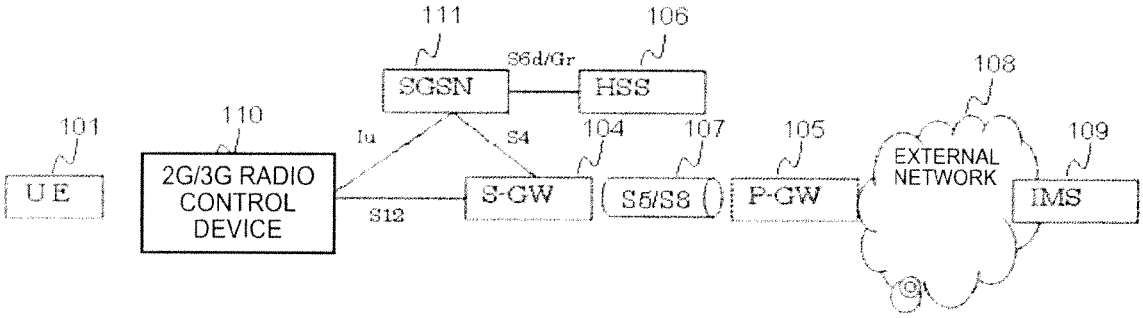

111
106
S6d/Gr
SGSN
HSS
108
101
110
Iu
S4
104
107
105
EXTERNAL NETWORK
109
UE
2G/3G RADIO CONTROL DEVICE
S12
S-GW
S5/S8
P-GW
IMS

FIG. 8

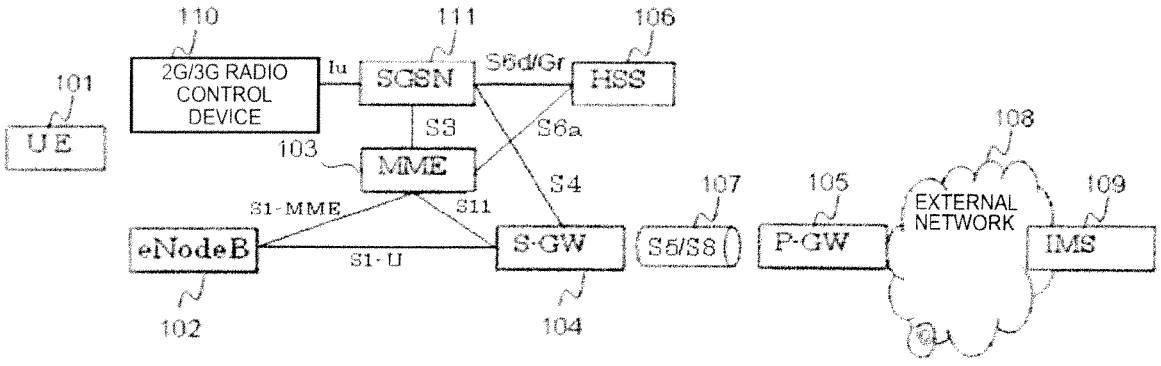

110
111
106
101
2G/3G RADIO CONTROL DEVICE
Iu
SGSN
S6d/Gr
HSS
UE
S3
S6a
103
MME
S4
107
105
108
109
S1-MME
S11
EXTERNAL NETWORK
eNodeB
S1-U
S-GW
S5/S8
P-GW
IMS
102
104

FIG. 9

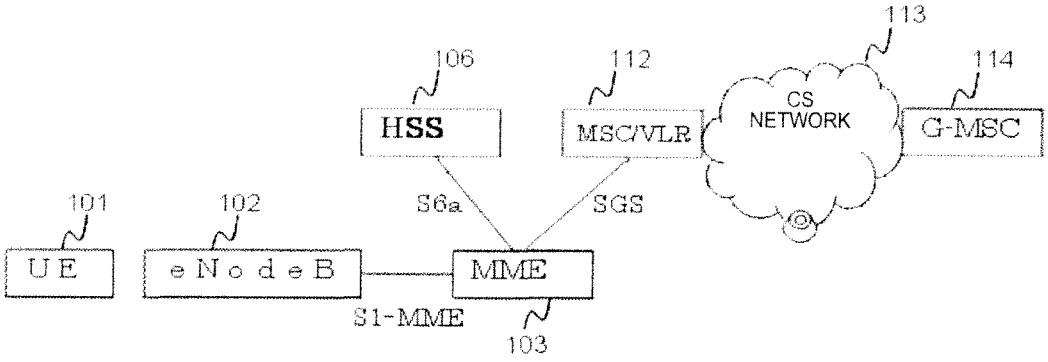

113
106
112
114
HSS
MSC/VLR
CS NETWORK
G-MSC
101
102
S6a
SGS
UE
eNodeB
MME
S1-MME
103

FIG. 10

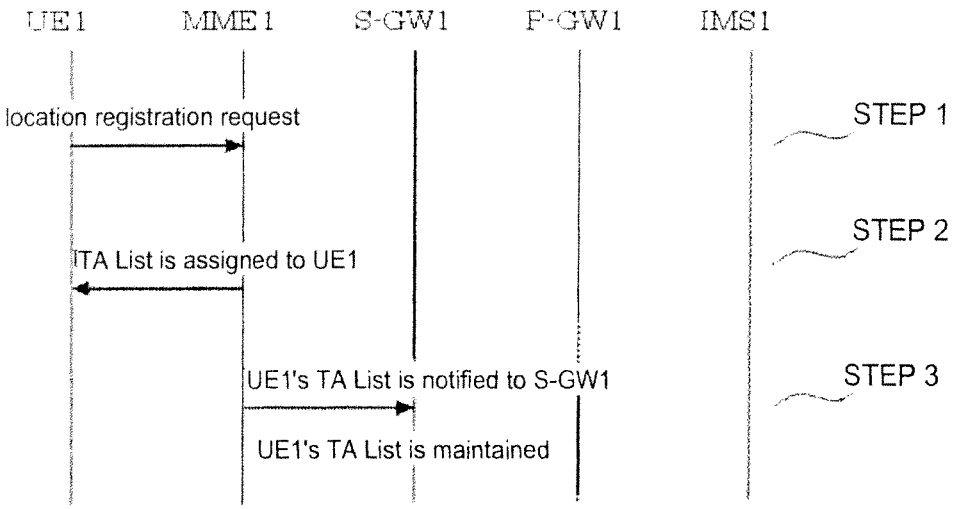

UE1
MME1
S-GW1
P-GW1
IMS1
location registration request
STEP 1
STEP 2
TA List is assigned to UE1
UE1's TA List is notified to S-GW1
STEP 3
UE1's TA List is maintained

FIG. 11

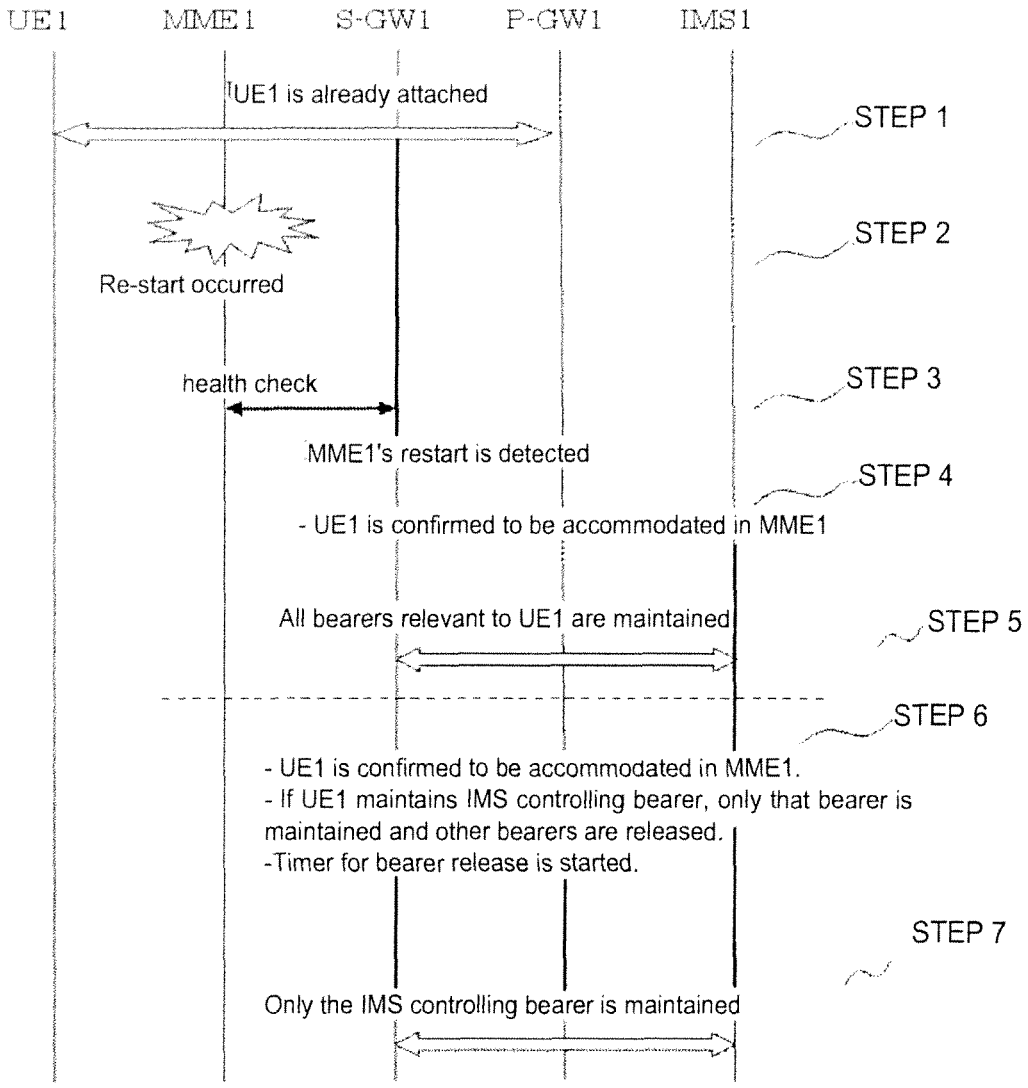

UE1
MME1
S-GW1
P-GW1
IMS1
UE1 is already attached
STEP 1
STEP 2
Re-start occurred
health check
STEP 3
MME1's restart is detected
STEP 4
- UE1 is confirmed to be accommodated in MME1
All bearers relevant to UE1 are maintained
STEP 5
STEP 6
- UE1 is confirmed to be accommodated in MME1.
- If UE1 maintains IMS controlling bearer, only that bearer is maintained and other bearers are released.
-Timer for bearer release is started.
STEP 7
Only the IMS controlling bearer is maintained

FIG. 12

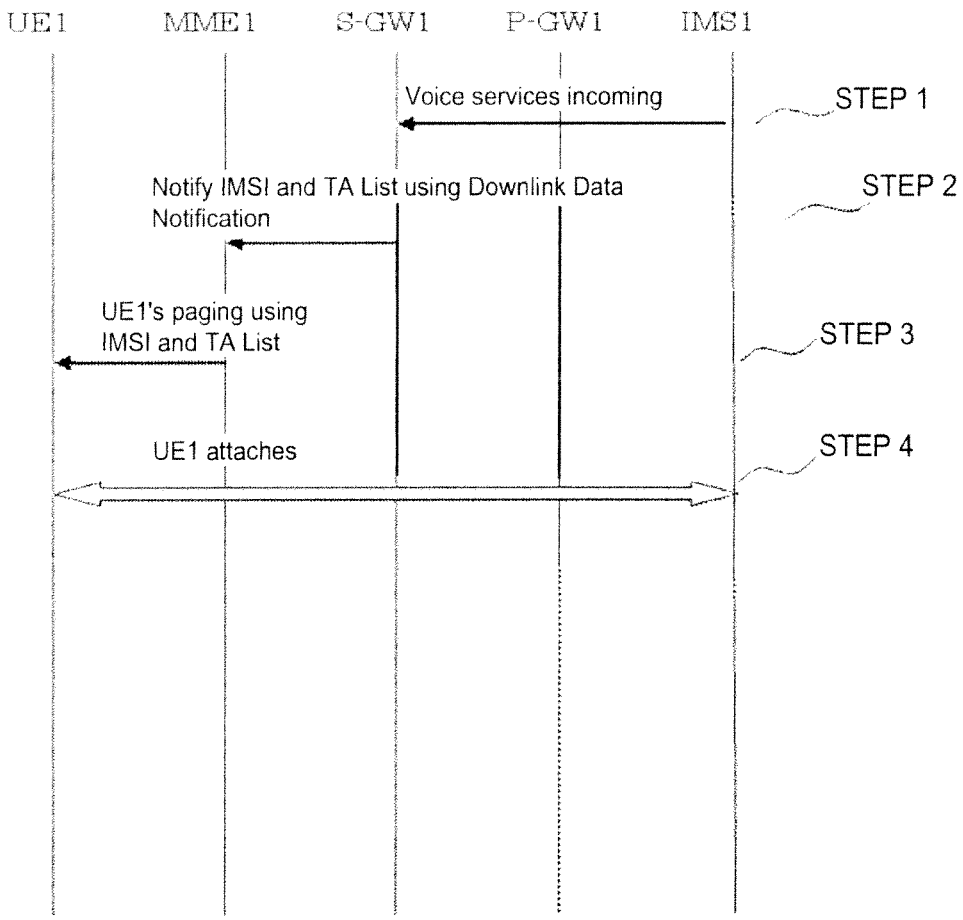

UE1
MME1
S-GW1
P-GW1
IMS1
Voice services incoming
STEP 1
Notify IMSI and TA List using Downlink Data Notification
STEP 2
UE1's paging using IMSI and TA List
STEP 3
UE1 attaches
STEP 4

FIG. 13

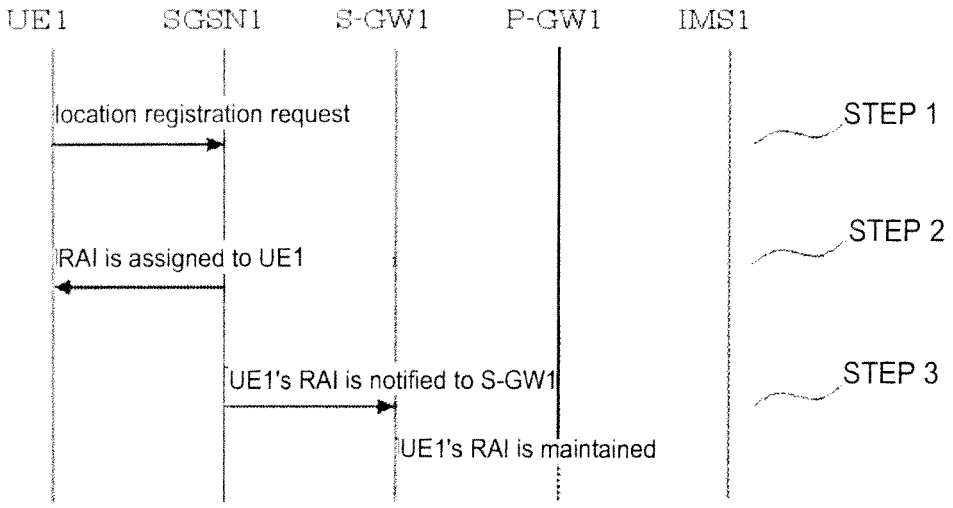

UE1
SGSN1
S-GW1
P-GW1
IMS1
location registration request
STEP 1
RAI is assigned to UE1
STEP 2
UE1's RAI is notified to S-GW1
STEP 3
UE1's RAI is maintained

FIG. 14

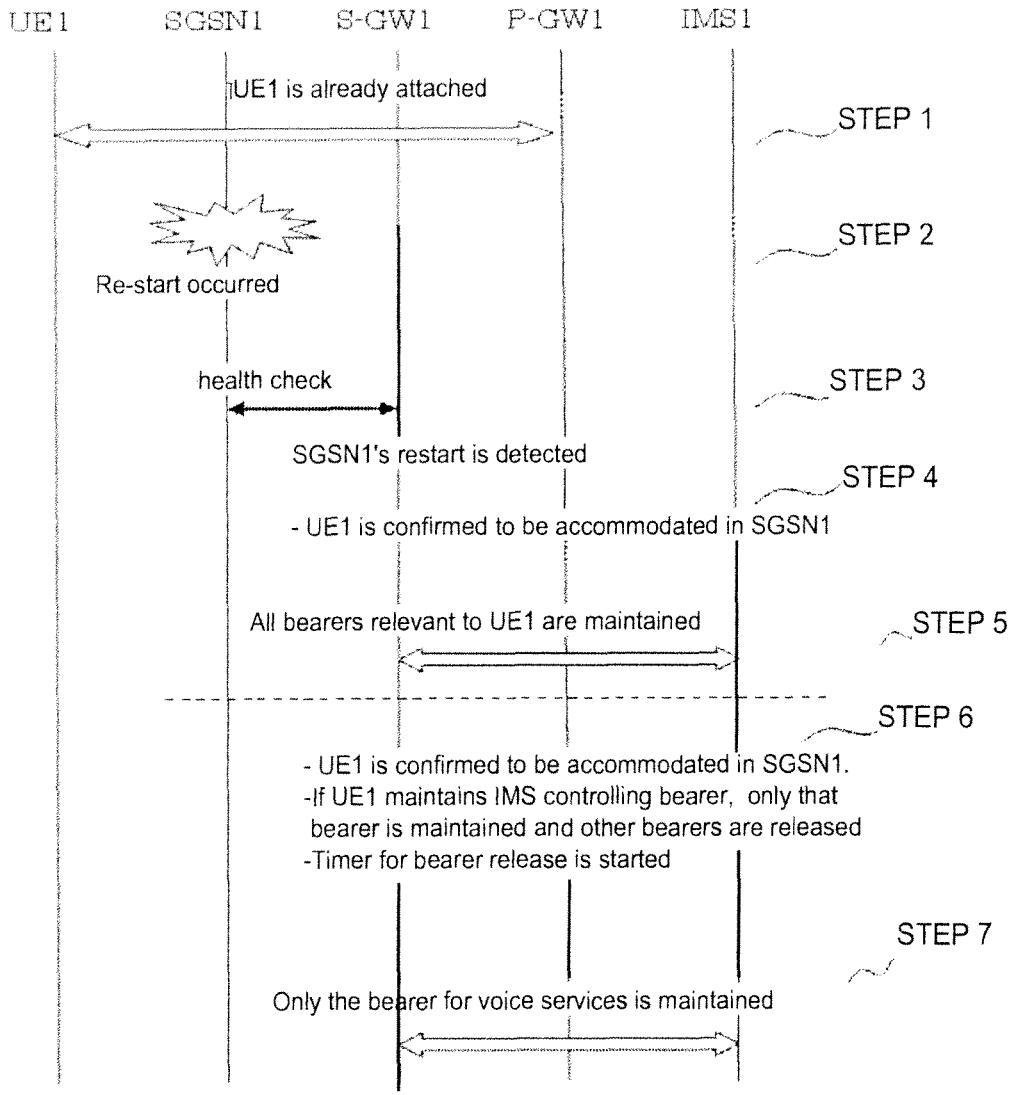

UE1
SGSN1
S-GW1
P-GW1
IMS1
UE1 is already attached
STEP 1
STEP 2
Re-start occurred
health check
STEP 3
SGSN1's restart is detected
STEP 4
- UE1 is confirmed to be accommodated in SGSN1
All bearers relevant to UE1 are maintained
STEP 5
STEP 6
- UE1 is confirmed to be accommodated in SGSN1.
-If UE1 maintains IMS controlling bearer, only that bearer is maintained and other bearers are released
-Timer for bearer release is started
STEP 7
Only the bearer for voice services is maintained

FIG. 15

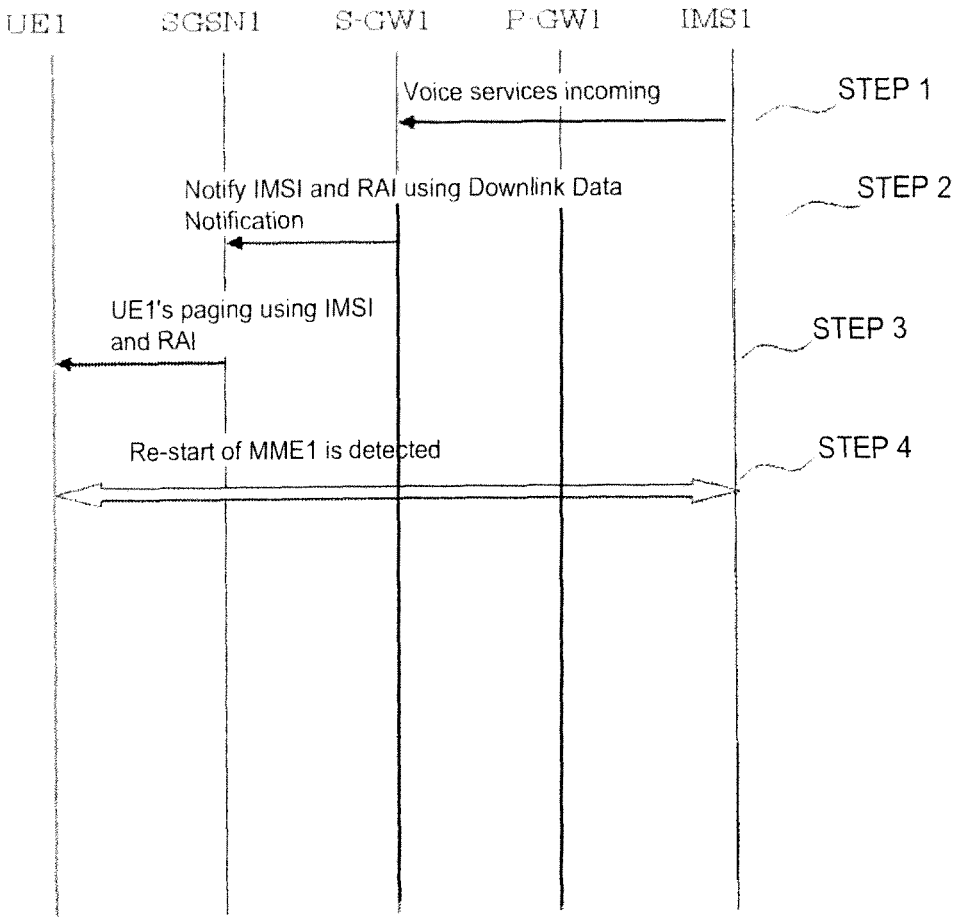

UE1
SGSN1
S-GW1
P-GW1
IMS1
Voice services incoming
STEP 1
Notify IMSI and RAI using Downlink Data Notification
STEP 2
UE1's paging using IMSI and RAI
STEP 3
Re-start of MME1 is detected
STEP 4

FIG. 16

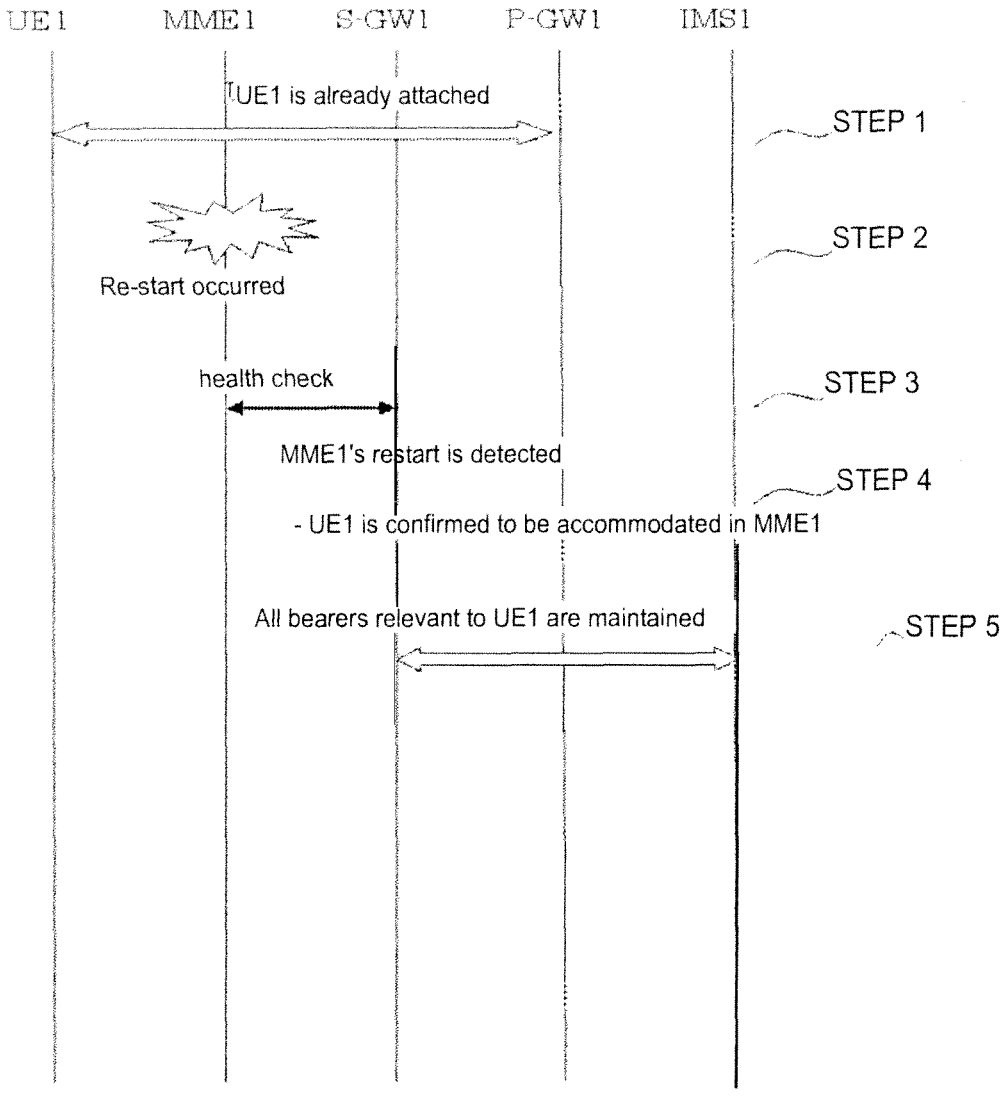

UE1
MME1
S-GW1
P-GW1
IMS1
UE1 is already attached
STEP 1
STEP 2
Re-start occurred
health check
STEP 3
MME1's restart is detected
STEP 4
- UE1 is confirmed to be accommodated in MME1
All bearers relevant to UE1 are maintained
STEP 5

FIG. 17

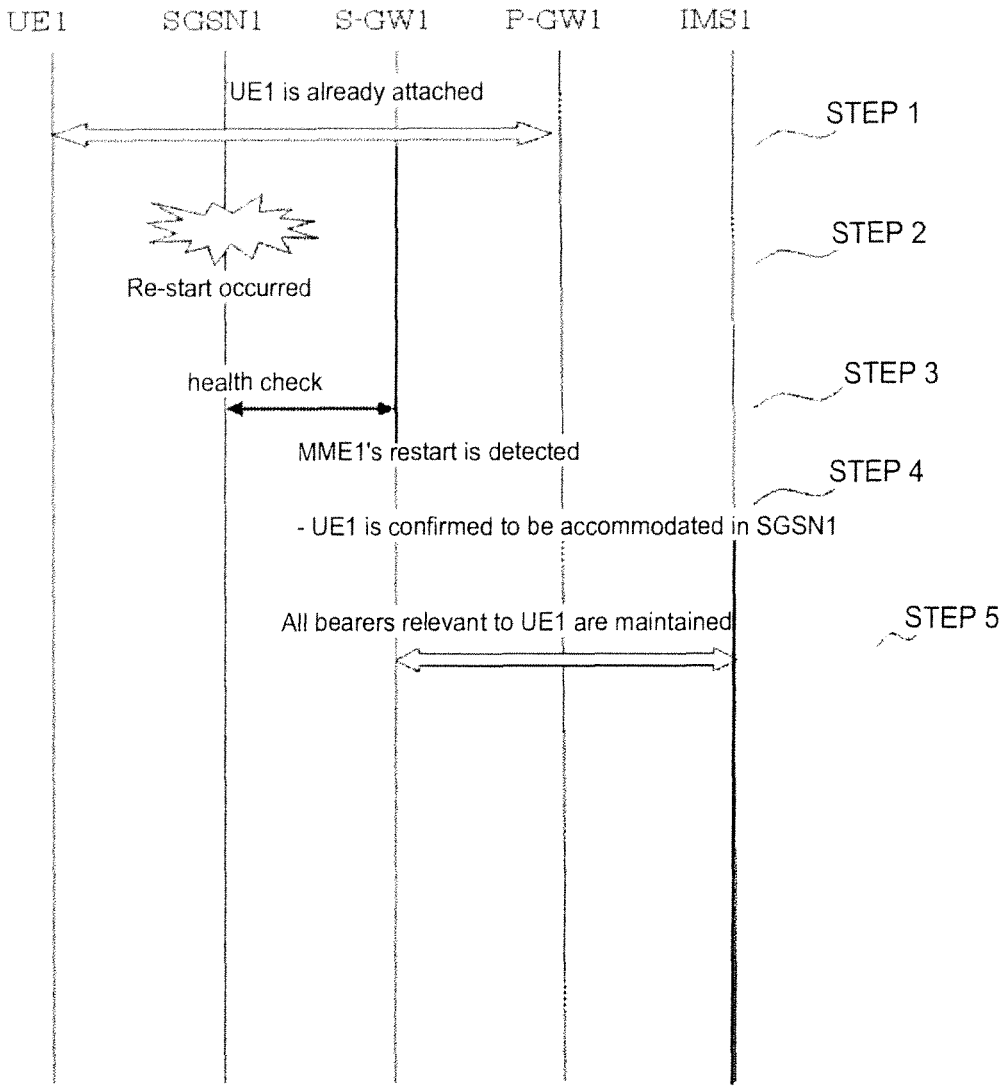

UE1
SGSN1
S-GW1
P-GW1
IMS1
UE1 is already attached
STEP 1
Re-start occurred
STEP 2
health check
STEP 3
MME1's restart is detected
STEP 4
- UE1 is confirmed to be accommodated in SGSN1
All bearers relevant to UE1 are maintained
STEP 5

FIG. 18

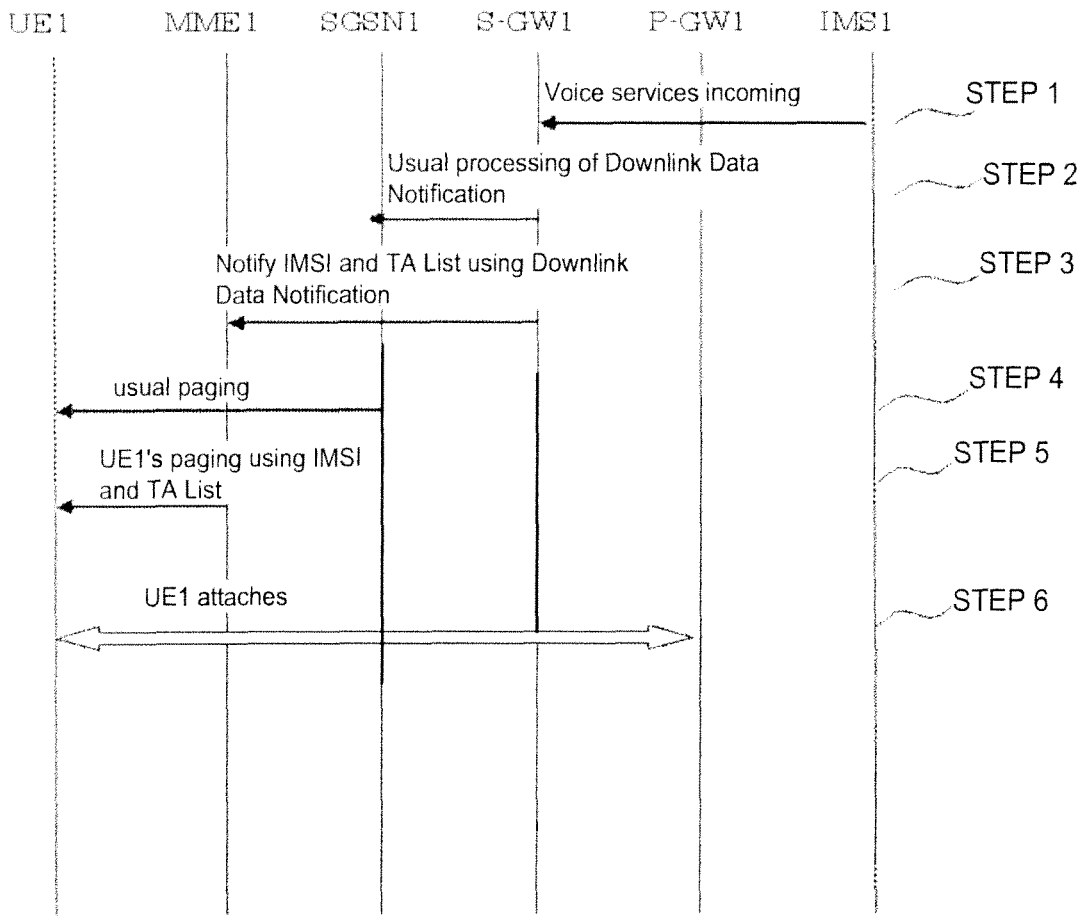

UE1
MME1
SGSN1
S-GW1
P-GW1
IMS1
Voice services incoming
STEP 1
Usual processing of Downlink Data Notification
STEP 2
Notify IMSI and TA List using Downlink Data Notification
STEP 3
usual paging
STEP 4
UE1's paging using IMSI and TA List
STEP 5
UE1 attaches
STEP 6

FIG. 19

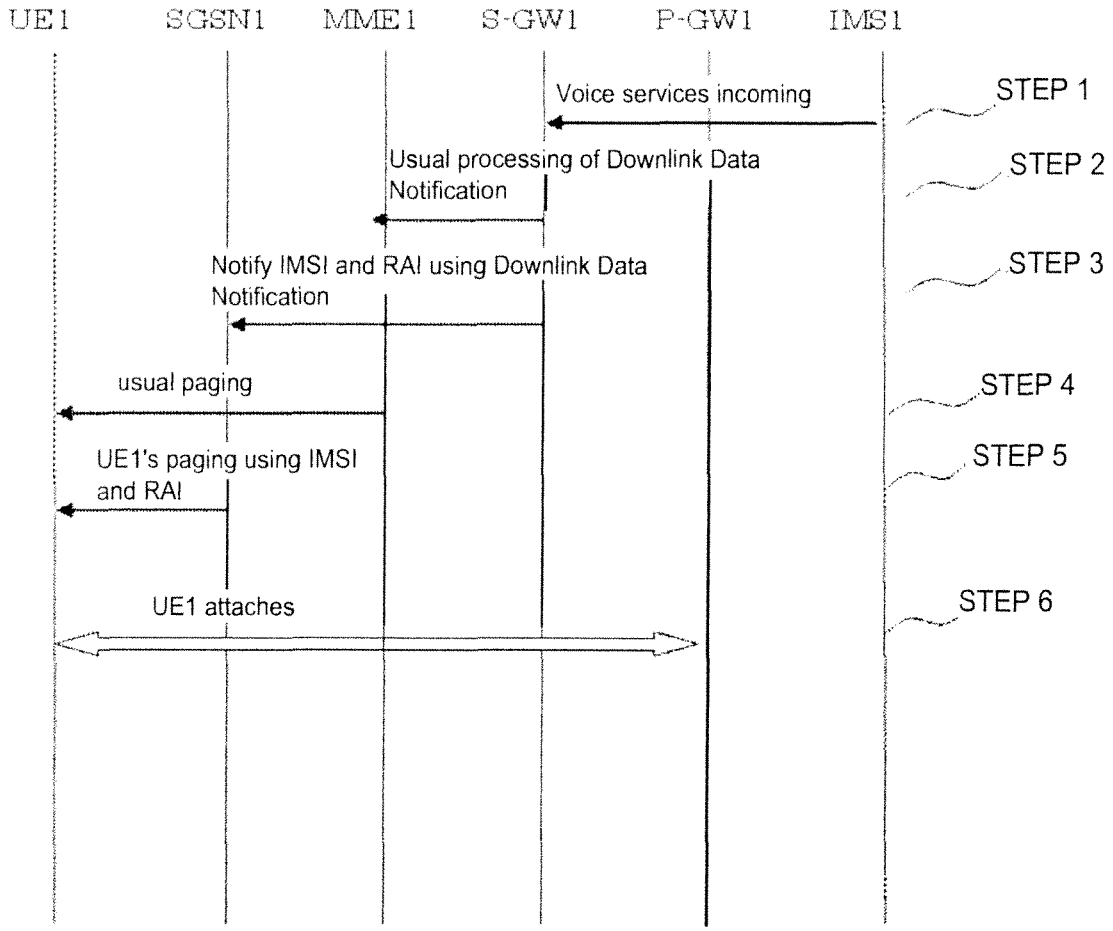

UE1
SGSN1
MME1
S-GW1
P-GW1
IMS1
Voice services incoming
STEP 1
Usual processing of Downlink Data Notification
STEP 2
Notify IMSI and RAI using Downlink Data Notification
STEP 3
usual paging
STEP 4
UE1's paging using IMSI and RAI
STEP 5
UE1 attaches
STEP 6

FIG. 20

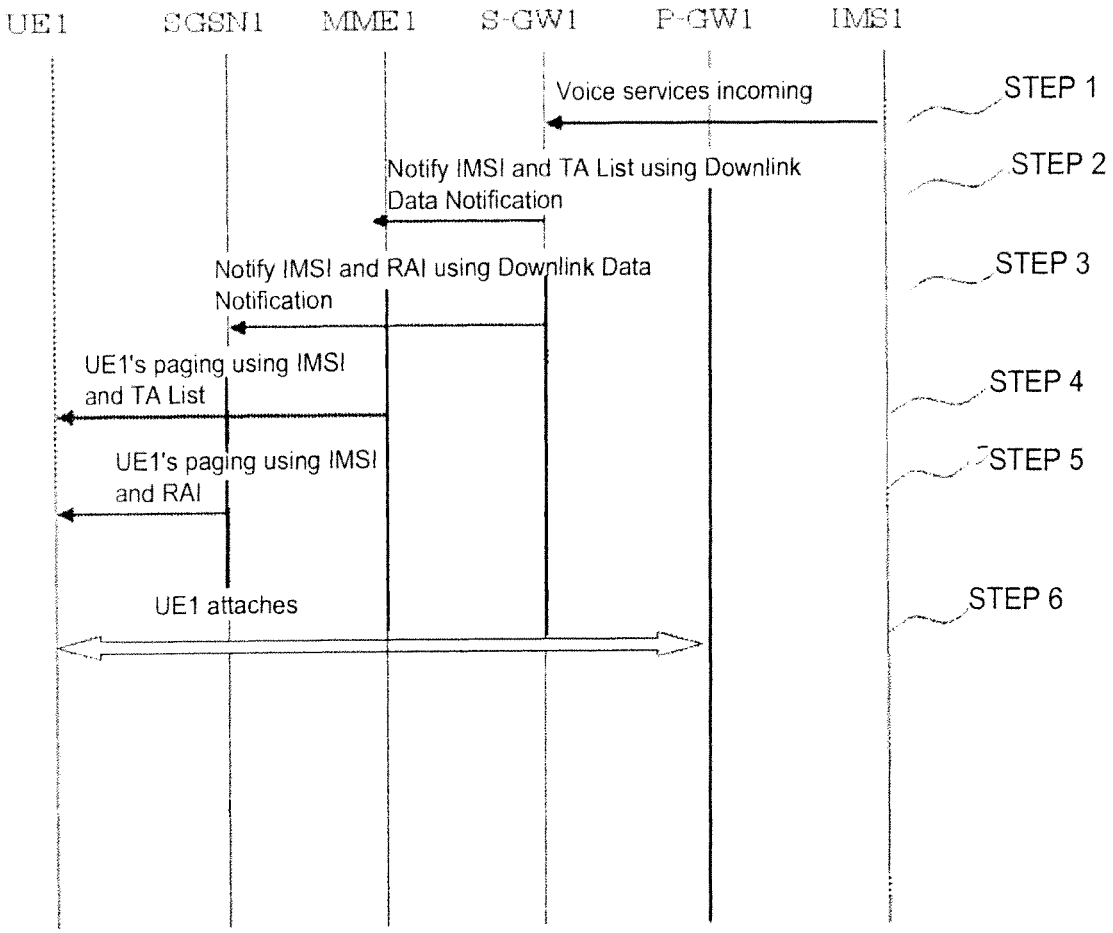

UE1
SGSN1
MME1
S-GW1
P-GW1
IMS1
Voice services incoming
STEP 1
Notify IMSI and TA List using Downlink Data Notification
STEP 2
Notify IMSI and RAI using Downlink Data Notification
STEP 3
UE1's paging using IMSI and TA List
STEP 4
UE1's paging using IMSI and RAI
STEP 5
UE1 attaches
STEP 6

FIG. 21

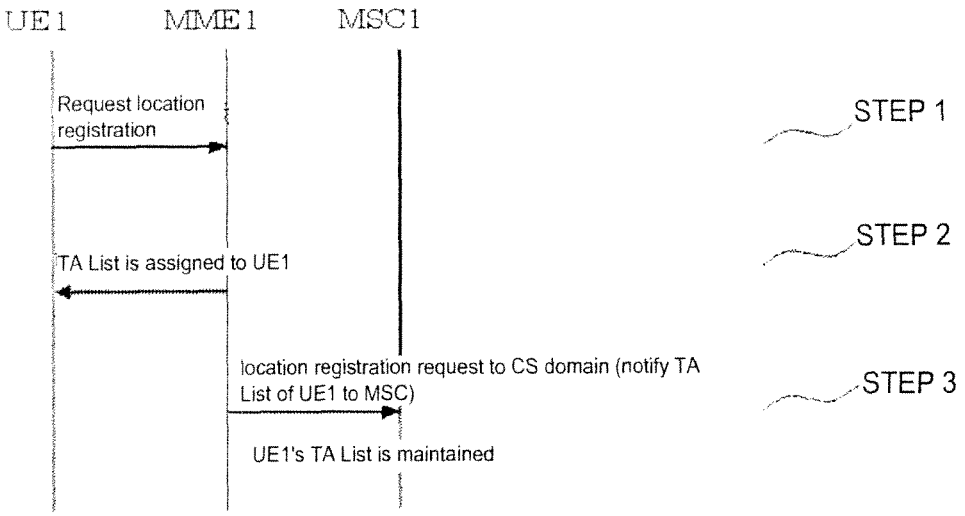

UE 1
MME 1
MSC 1
Request location registration
TA List is assigned to UE1
location registration request to CS domain (notify TA List of UE1 to MSC)
UE1's TA List is maintained
STEP 1
STEP 2
STEP 3

FIG. 22

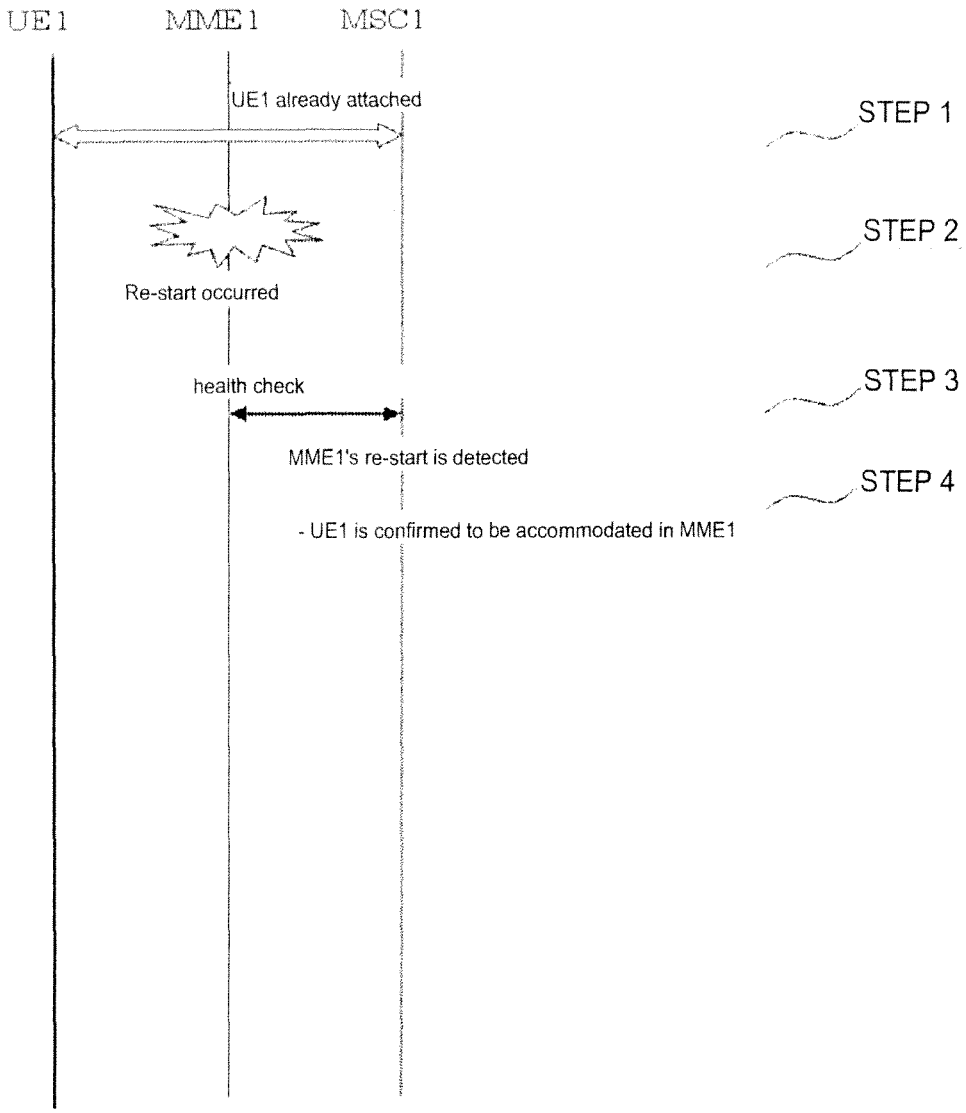

UE1
MME1
MSC1
UE1 already attached
STEP 1
STEP 2
Re-start occurred
health check
STEP 3
MME1's re-start is detected
STEP 4
- UE1 is confirmed to be accommodated in MME1

FIG. 23

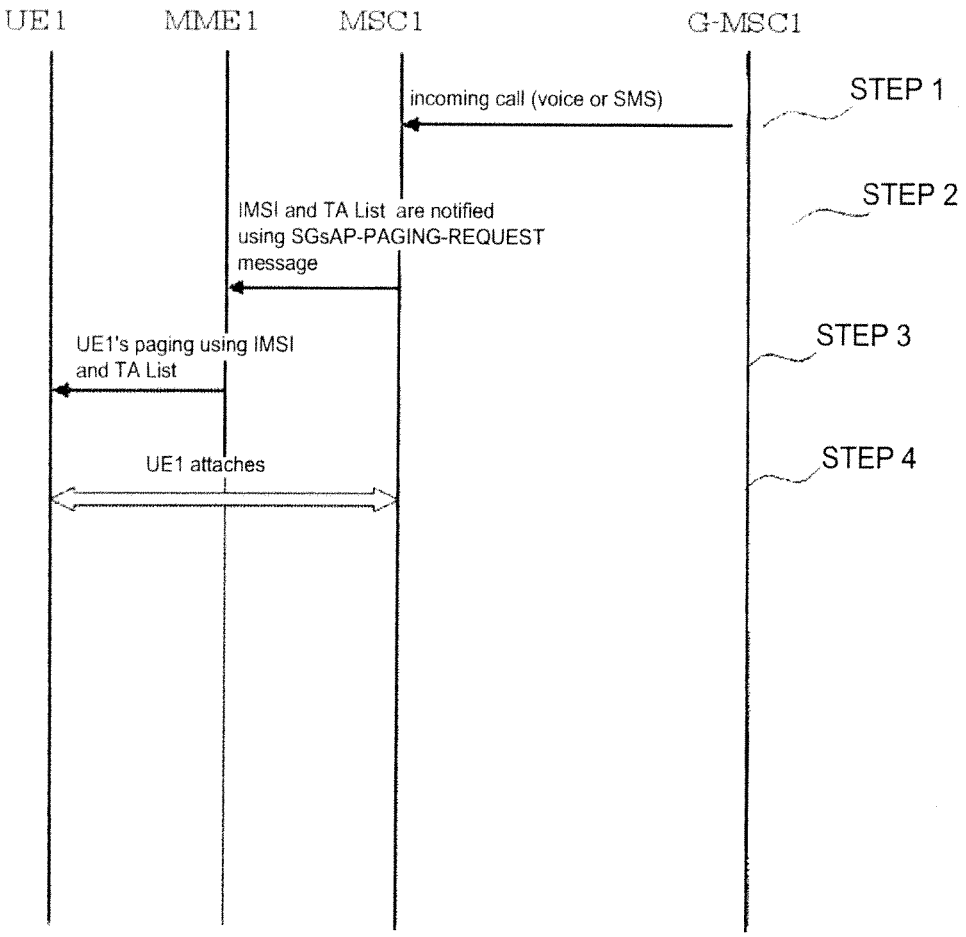
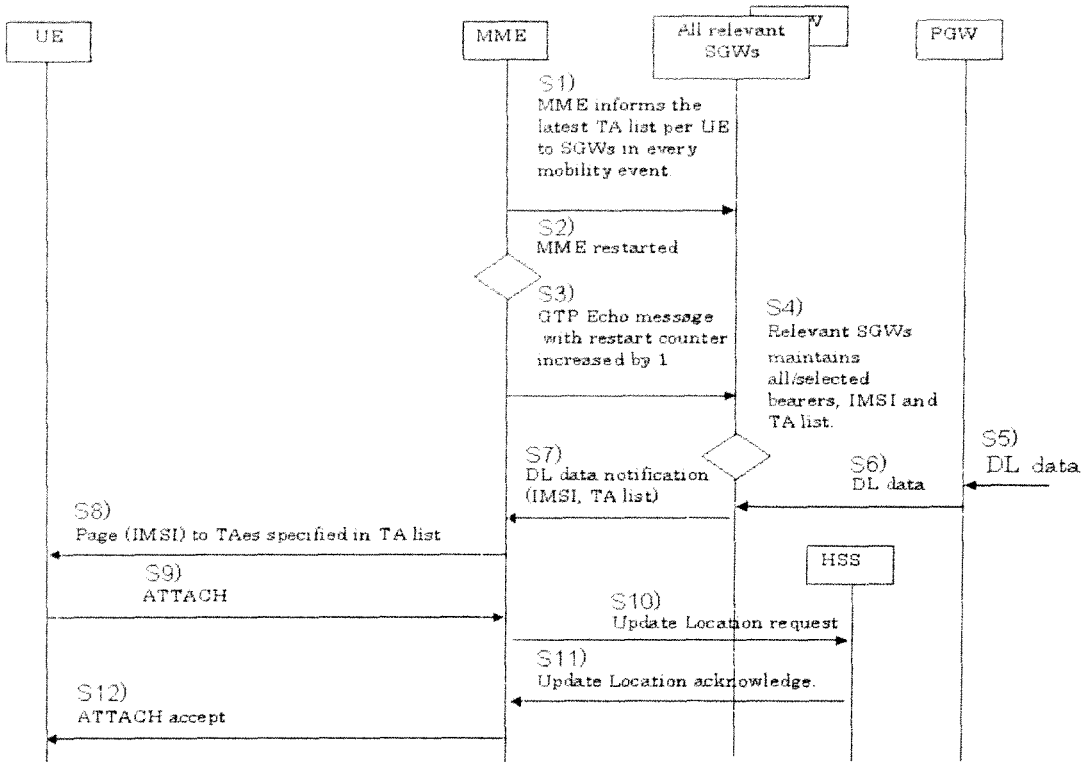

UE1
MME1
MSC1
G-MSC1
incoming call (voice or SMS)
STEP 1
IMSI and TA List are notified using SGsAP-PAGING-REQUEST message
STEP 2
UE1's paging using IMSI and TA List
STEP 3
UE1 attaches
STEP 4

FIG. 24


UE
MME
All relevant SGWs
PGW
S1)
MME informs the latest TA list per UE to SGWs in every mobility event.
S2)
MME restarted
S3)
GTP Echo message with restart counter increased by 1
S4)
Relevant SGWs maintains all/selected bearers, IMSI and TA list.
S5)
DL data
S6)
DL data
S7)
DL data notification (IMSI, TA list)
S8)
Page (IMSI) to TAes specified in TA list
S9)
ATTACH
HSS
S10)
Update Location request
S11)
Update Location acknowledge.
S12)
ATTACH accept

COMMUNICATION METHOD, MOBILE NETWORK SYSTEM AND DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a division of co-pending application Ser. No. 13/381,746 filed on Dec. 30, 2011, which is a National Stage of International Application No. PCT/JP2011/060215 filed on Apr. 27, 2011, which claims foreign priority to Japanese Patent Application No. 2010-102166 filed on Apr. 27, 2010. The total contents of disclosure of the patent application of the senior filing date are to be incorporated by reference into the present Application.

TECHNICAL FIELD

This invention relates to a communication network and, more particularly, to a system and a method as well as an apparatus that may be applied to advantage to the next-generation mobile network system EPC (Evolved Packet Core).

The following recites certain abbreviations used in the present specification.

CS: Circuit Switched
CSFB: Circuit Switched Fall Back
eNodeB (eNB): evolved NodeB
G-MSC: Gateway Mobile Switch Center
GPRS: General Packet Radio Service
GTP-C: (GPRS Tunneling Protocol Control Plane)
GTP-U: (GPRS Tunneling Protocol User Plane)
P-MIP: Proxy Mobile Internet Protocol
HSS: Home Subscriber Server
IMS: IP Multimedia Subsystem
IMSI: International Mobile-Station Subscription Identifier
ISR: Idlemode Signaling Reduction
LTE: Long Term Evolution
MME: Mobility Management Entity
MSC: Mobile Switching Center
MTC: Machine type communication
P-GW: (PGW or PDN-GW): Packet Data Network Gateway
PDN: Packet Data Network
QCI: QoS Class Identifier
RAI: Routing Area Identity
RNC: Radio Network Controller
S-GW (or SOW): Serving Gateway
SGSN: Serving GPRS Support Node
SMS: Short Message Service
SCPT: Stream Control Transmission Protocol
TA List: Tracking Area List
TAU: Tracking Area Update
TEID: Tunnel Endpoint Identifier
GRE key: Generic Routing Encapsulation Key
UE: User Equipment
UMTS: Universal Mobile Telecommunications System
VLR: Visited Location Register
3G: Third Generation
3GPP: 3rd Generation Partnership Project

BACKGROUND

The next-generation mobile network system EPC is a network architecture that accommodates 3G (third generation mobile phone communication system), LTE and so forth in one network. The following describes several network nodes.

A MME is a mobility management node. In LTE radio access, the MME takes charge of mobility management (mobility control), such as tracking, of an idle-mode mobile station (UE), authentication and setting up a user data forwarding path between an S-GW and a base station (eNodeB), in LTE radio access. The mobile station (UE) is also termed 'a user apparatus', 'a mobile terminal' or simply terminal'. The MME is involved in tracking and paging of idle-mode UEs or in bearer activate/deactivate processes. The MME selects the S-GW at the time of handover of the UE in LTE and performs user authentication along with HSS. It is noted that a bearer means a logical packet transmission path set up between eNodeB and S-GW/P-GW or the like.

An SGSN is a mobility management node in the 3G core network. It is a packet switching unit that takes charge of mobility management for the UEs, such as serving subscriber management, serving subscriber mobility management, originating/incoming call control, tunneling control, charging control, QoS (Quality of Service) control or the like.

When the UE is in an idle or power-saving state (LTE-idle) in an LTE core network, the UE is identified at the accuracy corresponding to a tracking area list (TA List) composed of a plurality of cells (MME maintains the latest updated TA List). At the time of an incoming call to the mobile station, paging is performed using the latest TA List registered last time. The SGSN of the 3G core network performs paging in an RA (Routing Area).

An S-GW performs routing and forwarding of a user data packet. The S-GW is a bearer management node that manages context of the UE (a parameter of IP bearer service or the like). In response to a bearer setting request from an MME that has received an attach request from the UE, The S-GW sets a path setting request for a P-GW and bearer in the direction of an eNode. The S-GW also performs triggering of a paging when the downlink (DL) data to a terminal has arrived.

A P-GW takes charge of connection of the UE to a packet data network (a service network: Web browsing service or an external network, such as IMS or the like.

The following describes restarting of MME/SGSN.

The 'restart' 'restart of MME/SGSN' means cessation of service due to failure, or intentional cessation of service for maintenance, that leads to initialization setting operation in the MME/SGSN, as a result of which, subscriber information or bearer information that is necessary for the MME/SGSN operation to operate is lost.

Non-Patent Document 2 (3GPP TS 23.007) provides that, when the S-GW detects that the MME/SGSN has restarted, the S-GW is to release bearer context of the UE registered in the MME/SGSN that has restarted. That is, According to Non-Patent Document 2, when the MME re-starts after failure, the MME removes the entirety of bearer contexts affected by the restarting. When the S-GW detects that the MME has restarted, the S-GW removes PDN connection table/bearer context corresponding to the MME that has restarted and releases inner resources relevant to the PND connection.

Assuming that an S-GW operates in accordance with the above specification of the Non-Patent Document 2, when the MME operation has restarted, the S-GW is unable to effect a packet incoming operation to the UE until originating a call by the mobile station itself or periodic location registration (e.g., Attach/TAU Request) periodically by performed by the UE itself to the MME.

When there is an incoming call to the UE, the network performs paging all at once to whole cells associated with an area where the UE has made location registration (tracking area). The so paged UE accesses a serving cell and establishes a call. However, according to the specification of Non-Patent Document 2, the entirety of bearer information or resources of the restarted MME has already been removed or released.

That is, in the S-GW, radio access bearers in the direction of from the S-GW to the eNodeB and session information between the MME and the S-GW have been removed or released, so that when the incoming packet data to the UE is received only to no effect.

In the S-GW in this state, TEID or GRE Key, as the identification information of a tunnel (GTP-U or P-MIP), a transport protocol between the S-GW and the P-GW, also has been removed. Hence, in the S-GW, the incoming data is rejected. The P-GW also removes relevant resources in response to the rejection of the incoming packet data from the S-GW.

Non-Patent Document 1:

3GPP TS 23.203 V9.4.0 (2010-03) 3rd Generation Partnership Project: Technical Specification Group Services and System Aspects: Policy and charging control architecture (Release 9), page 31, Table 6.1.7: Standardized QCI characteristics

Non-Patent Document 2:

3GPP TS 23.007 V9.3.0 (2010-03) 3rd Generation Partnership Project: Technical Specification Group Core Network and Terminals; Restoration procedures (Release 9), pages 27-28

Non-Patent Document 3:

3GPP TS 23.272 V9.3.0 (2010-03) 3rd Generation Partnership Project: Technical Specification Group Services and System Aspect; Circuit Switched (CS) fallback In Evolved Packet System (EPS); Stage 2 (Release 9) pages 26-27

SUMMARY

The disclosures of the Non-Patent Documents 1 to 3 are incorporated by reference into the present specification. The following is an analysis of the related techniques.

In case the S-GW operates in accordance with the above specification of Non-Patent Document 2, as described above, the S-GW which has detected the restarting of the mobility management node MME/SGSN releases entirety of hearers of the UE registered in the MME/SGSN where restarting occurred.

Hence, the incoming to the UE after the restarting of the mobility management node MME/SGSN may not be informed to the UE until such time the attach operation for registration in the network is carried out in the UE. That is, if, during the time that elapses after restarting of the MME/SGSN until the end of the attachment operation, triggered by the origination by the UE itself or the periodic location registration by the UE, the UE is unable to have a communication service, even if there is an incoming of the communication service. For example, during a time interval of the periodic location registration (TAU request) (e.g., up to 45 minutes), following the restarting of the MME/SGSN, incoming packet data, addressed to the UE, may not be delivered to the UE.

That is, a packet communication service is at a standstill. This poses a serious problem since communication services as social infrastructure may not be received for a preset time in case IMS is exploited on an EPS network.

Accordingly, it is an object of the present invention to provide a system, a method and an apparatus which enable to accelerate restoration of communication services for a mobile terminal (UE) after restarting of a mobility management entity (MME).

In accordance with one aspect of the present invention, there is provided a mobile terminal (UE) used in a mobile communication network that includes a mobility management entity (MME) and a serving gateway (S-GW), the mobile terminal comprising:

a receiver that receives paging from the mobile communication network, upon an arrival of an incoming call destined for the mobile terminal at the mobile communication network with the serving gateway, upon restarting of the mobility management entity, maintaining a specific S5/S8 bearer for a preset time period prescribed by a timer, the serving gateway deleting the specific S5/S8 bearer on timeout of the timer; and

a transmitter that in response to the paging, re-attaches to the mobile communication network.

In accordance with one aspect of the present invention, there is provided a communication method in which a bearer management node maintains a specific bearer eligible for restoration of communication services, and removes the other hearers. In case a mobility management node is restarted, the bearer management node maintains at least one bearer.

In accordance with another aspect of the present invention, there is provided a method for registration of a mobile terminal (UE) in a mobile communication network that includes a mobility management entity (MME) and a serving gateway (S-GW), the method comprising:

receiving, by the mobile terminal, paging from the mobile communication network, upon an arrival of an incoming call destined for the mobile terminal at the mobile communication network with the serving gateway, upon restarting of the mobility management entity, maintaining a specific S5/S8 bearer for a preset time period prescribed by a timer, the serving gateway deleting the specific S5/S8 bearer on timeout of the timer; and

re-attaching to the mobile communication network, by the mobile terminal, in response to receipt of the paging.

In accordance with another aspect of the present invention, there is provided a communication method wherein, on restarting of a mobility management node, a circuit switched node sends to the mobility management node a notification message including identification information associated with the UE and location registration area information, and the mobility management node starts paging, inclusive of the identification information associated with the UE, for an area corresponding to the location registration area information.

According to the present invention, there is also provided a mobile network system in which a bearer management node maintains a specific bearer eligible for restoration of communication services, and removes other bearers. The mobile network system includes a mobility management node and a bearer management node. When restarting of the mobility management node is performed, the bearer management node maintains at least one of the bearers as set.

According to the present invention, there is provided a mobile network system comprising a mobility management node and a circuit switched node. In case restarting of the mobility management node is performed, the circuit switched node sends to the mobility management node a notification message inclusive of the identification information associated with the UE and the location registration area information. The management node performs paging including the identification information associated with the UE for an area corresponding to the location registration area information.

According to the present invention, there is provided a node apparatus that manages a bearer, wherein the node apparatus maintains a specific bearer eligible for restoration of communication services, and removes other bearers. In case restarting of the mobility management node is performed, the node apparatus maintains at least one of the bearers as set.

According to the present invention, it is possible to accelerate restoration of a communication service for a mobile station following restarting of a mobility management node.

Still other features and advantages of the present invention will become readily apparent to those skilled in this art from the following detailed description in conjunction with the accompanying drawings wherein only exemplary embodiments of the invention are shown and described, simply by way of illustration of the best mode contemplated of carrying out this invention. As will be realized, the invention is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the invention. Accordingly, the drawing and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram for illustrating the operation of a mode of the present invention.

FIG. **2** is another diagram for illustrating the operation of the mode of the present invention.

FIG. **3** is yet another diagram for illustrating the operation of the mode of the present invention.

FIG. **4** is yet another diagram for illustrating the operation of the mode of the present invention.

FIG. **5** is yet another diagram for illustrating the operation of the mode of the present invention.

FIG. **6** is a diagram for illustrating a packet communication network that accommodates LTE.

FIG. **7** is a diagram for illustrating a packet communication network that accommodates 2G/3G.

FIG. **8** is a diagram for illustrating a packet communication network that accommodates LTE and 2G/3G.

FIG. **9** is a diagram for illustrating CSFB (Circuit Switch Fall Back).

FIG. **10** is a diagram for illustrating an example sequence of an exemplary embodiment 1 of the present invention.

FIG. **11** is a diagram for illustrating another example sequence of the exemplary embodiment 1 of the present invention.

FIG. **12** is a diagram for illustrating yet another example sequence of the exemplary embodiment 1 of the present invention.

FIG. **13** is a diagram for illustrating an example operating sequence of an exemplary embodiment 2 of the present invention.

FIG. **14** is a diagram for illustrating another example operating sequence of the exemplary embodiment 2 of the present invention.

FIG. **15** is a diagram for illustrating yet another example operating sequence of the exemplary embodiment 2 of the present invention.

FIG. **16** is a diagram for illustrating an example operating sequence of an exemplary embodiment 3 of the present invention.

FIG. **17** is a diagram for illustrating another example operating sequence of the exemplary embodiment 3 of the present invention.

FIG. **18** is a diagram for illustrating an example operating sequence of an exemplary embodiment 4 of the present invention.

FIG. **19** is a diagram for illustrating another example operating sequence of the exemplary embodiment 4 of the present invention.

FIG. **20** is a diagram for illustrating yet another example operating sequence of the exemplary embodiment 4 of the present invention.

FIG. **21** is a diagram for illustrating an example operating sequence of an exemplary embodiment 5 of the present invention.

FIG. **22** is a diagram for illustrating another example operating sequence of the exemplary embodiment 5 of the present invention.

FIG. **23** is a diagram for illustrating yet another example operating sequence of the exemplary embodiment 5 of the present invention.

FIG. **24** is a diagram for illustrating an example operating sequence of a mode of the present invention.

PREFERRED MODES

In one of preferred modes of the present invention, when a mobility management node, such as the MME/SGSN, has restarted, a bearer management node (S-GW) does not release all of bearers relevant to the mobility management node (MME/SGSN). The bearer management node (S-GW) holds at least part of or entirety of bearers to continue a packet incoming service. That is, when the bearer management node, such as the S-GW, detects restarting of the mobility management node (MME/SGSN), the bearer management node confirms that UE is accommodated in the mobility management node (MME/SGSN). In connection with the UE, accommodated in the mobility management node (MME/SGSN), the bearer management node, such as S-GW, retains at least one of bearers set between the bearer management node (S-GW) and the external network, such as PDN. By so doing, the UE is able to attach to the network, with packet incoming from the external network (PDN) to the UE as a trigger, thereby accelerating the restoration of a communication service for the UE. In one of preferred modes of the present invention, the bearer management node maintains a specific bearer(s) for restoring a communication service, and removes other bearers. In one of preferred modes of the present invention, when maintaining the specific bearer, the bearer management node may start a timer. On timeout of the timer, the bearer management node may remove hearer resources that have been maintained.

In one of preferred modes of the present invention, it is possible to select those bearers that render services of high reliability after restarting of the mobility management node (MME/SGSN). It is thus possible to suppress consumption of resources of the bearer management node (S-GW) as well as to avoid congestion due to massive location registration signals.

In one of preferred modes of the present invention, the bearer management node S-GW maintains the location registration area information (TA List/RAI) of the UE, informed from the mobility management node (MME/SGSN), and the identification information (IMSI) associated with the UE. After restarting of the mobility management node (MME/SGSN), the bearer management node (S-GW) may, on receipt of incoming data to the UE, notify the location registration area information (TA list/RAI) and the identification information (IMSI) to the mobility management node (MME/SGSN). The mobility management node (MME/SGSN) may then perform paging, using the identification information (IMSI), for only the area corresponding to the location registration area information (TA list/RAI). By so doing, it is possible to selectively reduce an area that is paged by the base station.

FIG. **1** is a diagram for illustrating one of modes of the present invention. A mobility management node MME/SGSN that manages registration information of a mobile station UE, notifies the location registration information of the LIE to an S-GW at the outset. The S-GW maintains the

location registration information of the UE. The S-GW also maintains bearers between the S-GW and the P-GW.

Restarting occurs at the mobility management node MME/SGSN.

When the S-GW detects, by e.g., health check, that the mobility management node (MME/SGSN) has restarted, the S-GW does not release but maintains bearers that are set between the S-GW and the P-GW. In this case, in view of compatibility of the stable system restoration and availability of communication services, it is possible for the S-GW not to release but continue to maintain those bearers that will provide for high availability services. These services may be exemplified by communication that is in need of high reliability in accordance with, e.g., of the operator policy, such as voice services provided by IMS. For example, the S-GW may not release but maintain specific S5/S8 bearers between the S-GW and the P-GW, necessary for restoration of services initiated from the network side, and to delete all the other S5/S8 bearers.

In an example shown in FIG. **2**, when the S-GW detects, by e.g., health check (GTP-echo), that the mobility management node MME/SGSN has restarted, the S-GW releases IMS control bearer services, among bearers set between the S-GW and the P-GW, while maintaining just the bearers used for IMS signaling. By thus applying to just specific services, it is also possible to gradually restore the MME/SGSN while overload on the entire system is avoided.

FIG. **3** is a diagram for illustrating the case of applying the present invention to IMS services. When packet data has arrived, using the bearer held by the S-GW, the packet incoming is notified, along with the IMSI identifying the UE and the location registration area information, registered beforehand in the S-GW, to the MME/SGSN where the restarting has occurred. The MME/SGSN is thus able to call (page) the UE using the IMSI and the location registration area information. The mobile station UE that has been paged using the IMSI, performs re-registering (attach) to the MME/SGSN and re-establishes necessary bearers to receive the entirety of packet communication services. Thus, according to a mode of the present invention, even if the MME/SGSN restarts, service arrival may be notified to the UE to prompt its attachment to the MME to improve availability of communication services.

According to a mode of the present invention, it is possible to cause a UE to attach to the network, after restarting of the MME/SGSN, with the incoming of the packet to the UE as a trigger. Packet communication services may instantaneously be restored to the UE whose services have been started by the arrival of the incoming packet.

In a mode of the present invention, just those bearers that need high reliability may be taken as bearers to be maintained according to the present invention. It is thus possible to suppress consumption of S-GW resources as well as congestion due to massive location registration signals. This operation is indispensable especially in case a UE where packet communication occurs periodically, as in MTC, is accommodated. The reason is that, in such case, packet communication occurs for many UEs after restarting of the MME/SGSN, and hence the subscriber recovering operations may occur in a burst fashion, with the packet communication as a trigger, thus possibly leading to congestion of the system in its entirety.

FIGS. **4** and **5** are diagrams showing an example in which the present invention is applied to CSFB. The CSFB function switches voice origination/incoming to 3G to render voice services employing the 3G-CS domain even in case VoIP services are not provided on LTE. As regards the CSFB function, reference is to be made to Non-Patent Document 3 (FIG. 7.2—1 Mobile Termination Call in idle mode).

Referring to FIG. **4**, the MME notifies the UE's location registration information to an MSC in advance. When the MME restarts, the MSC detects the restarting of the MME by e.g., health check. Referring to FIG. **5**, when a call arrived from an originating side G-MSC (CS incoming), the MSC notifies the IMSI and the location registration area to the MME, which MME is able to call (page) the UE using the IMSI and the location registration area information.

The following describes exemplary embodiments of the present invention. FIGS. **6** to **9** show networks to which the present invention may be applied.

Exemplary Embodiment 1

FIG. **6** is a diagram showing a network configuration of an exemplary embodiment 1 of the present invention. Specifically, FIG. **6** shows a packet communication network that accommodates LTE. Referring to FIG. **6**, the network includes a UE **101**, a base station (eNodeB) **102**, a MME **103**, an HSS **106**, an S-GW **104**, a P-GW **105**, an external network (PDN) **108** and an IMS **109**. The IMS **109** is a communication system that integrates packet switched communication services by SIP (Session Initiation Protocol) to implement multimedia services.

The MME **103** accommodates the eNodeB **102** by an S1-MME interface to perform UE mobility management and authentication as well as setting of a user forwarding path. The MME **103** refers to the HSS **106** that is a database for managing subscriber information, through an S6a interface, to perform e.g., authentication. The MME **103** transmits/receives a control signal via S1-MME and S11 interfaces to set up or release the user forwarding path on an S1-U interface between the eNodeB and the S-GW. The transport protocol at the S1-U interface between the eNodeB and the S-GW is GTP-U.

An S5/S8 interface **107** is an interface (user plane) between S-GW and P-GW. As a transport protocol, a tunneling protocol (GTP-U) or a proxy mobile IP protocol (P-MIP), is set.

The S-GW **104** performs user data transmission/reception between it and the eNodeB **102**, while setting up or releasing an external PDN based transmission path via P-GW and S5/S8 interface **107**. The P-GW **105** connects to the external network (PDN) **108** over an SGi interface. The following describes an operation when the MME restarts.

<First Stage>

FIG. **10** is a sequence diagram that illustrates, as a first stage, a stage of registering location registration area information of the UE in the S-GW. In FIG. **10**, the base station (eNodeB) **102** of FIG. **6** is omitted. It is premised that the UE**1** has set up a radio control link between it and the eNodeB. The respective steps of FIG. **10** will now be described.

In a step **1** of FIG. **10**, the UE**1** transmits a location registration request (Attach Request or TAU Request) to the MME **1**. Note that, in LTE, the location of the UE in an idle (standby) mode is managed per location registration area information (tracking area). Each tracking area corresponds to a location area or a routing area in 3G/UMTS, and is composed of one or a plurality of cells. In each of these cells, an identifier of the tracking area to which the cell in question belongs is broadcasted. The mobile station in an idle mode has its location registered in the tracking area in which the UE resides, and stores the identifier of the tracking area in which the UE has its location currently registered. When moving from one cell to another, the UE receives the identifier of the tracking area which is broadcasted. In case the identifier of the tracking area being broadcasted differs from the identifier of the tracking area, currently registered therein, the UE updates location registration. A request for update of this location registration is termed a 'TAU Request'.

In a step S2 of FIG. 10, the MME 1 newly assigns the location registration area information (TA List) to the UE1.

In a step S3 of FIG. 10, the MME 1 informs the S-GW1 about the TA List of the UE1 via S11 interface. The S-GW1 stores the TA List, informed from the MME 1, in a storage unit (memory) in the S-GW1, as the registration information of the UE1.

It is noted that the location registration operation in the steps 1 and 2 of FIG. 10 is known per se and is not directly relevant to the subject-matter of the present invention. Hence, the operation is not explained in detail.

<Second Stage>

FIG. 11 is a sequence diagram for illustrating, as a second stage, the stage of maintaining a bearer. In a step 1 of FIG. 11, the UE1 has already attached to the MME1 (an attach request has already been issued). A variety of bearers have already been set up using S-GW1 and P-GW1.

In a step 2 of FIG. 11, the restarting of the MME1 occurs and in this MME1, the registration information of the UE1, already attached, is erased.

In a step 3 of FIG. 11, the S-GW1 detects the restarting of the MME1, from processing such as a health check by GTP Echo processing.

In a step 4 of FIG. 11, S-GW1 recognizes all mobile stations UE attached to the MME 1 is confirmed that the UE1 is accommodated in the MME 1).

In case the present invention is provided for the entirety of the services, all bearers related with the UE1 from the S-GW1 towards the external network IMS 1 are maintained in the step S5 of FIG. 11.

In steps 6 and 7 of FIG. 11, in distinction from the step S5 of FIG. 11, the bearer maintaining function according to the present invention is not provided for all services relating to the UE1, such that bearers (bearers used for IMS signaling) are maintained for specific services (IMS services providing e.g., voice services).

After confirming in the step S4 of FIG. 11 that the UE1 has been accommodated in the MME 1, the S-GW1 further confirms, in the step 6 of FIG. 11, whether or not there is a bearer(s) providing the IMS (bearer(s) used for IMS signaling) among the bearers owned by the UE1. In verifying the bearers used for IMS control in this manner, a QCI (QoS Class Identifier) value, which is among information elements that each bearer has, may be used. If, in using the QCI value, it is '5', for example, the bearer may be concluded to be the bearer(s) used for IMS signaling (IMS Signaling), in accordance with the Table 6.1.7 of Non-Patent Document 1 (3GPP TS23.03). The bearer may then be concluded to be a control bearer used for rendering voice services.

If there is the control bearer(s) used for IMS signaling among the bearers relating to the UE1 managed by the S-GW1, only the relevant bearer(s) are maintained. The remaining bearers are locally released in accordance with the operation in accordance with Non-Patent Document 2 (3GPP TS23.007).

In case of maintaining the bearers used for IMS signaling (specific bearers), the S-GW1 starts the operation of a timer to release (remove) relevant bearer resources on timeout, in consideration of a case where the UE1 has already re-attached to another S-GW. This timer controls a time of maintaining the above mentioned specific bearer by the S-GW1, and becomes necessary to prevent failing to release the bearers that the S-GW1 maintains. If, in the above timer, the time equivalent to the time of a periodic location registration timer owned by the UE1 is set, the S-GW1 may wait for incoming of voice services for a necessary minimum time interval corresponding to the time of the next periodic location registration request from the UE1. At this time, the fact that the UE1 has not been registered in the MME1 is stored in the storage unit (memory) of the S-GW1.

In a step 7 of FIG. 11, the UE1 is not registered in the MME 1 and only the IMS control bearer is maintained in the S-GW1 and in the P-GW1. This completes the second stage.

If the third stage, shown in FIG. 12, has not been carried out thereafter, the S-GW1 removes the entirety of bearers (IMS control bearer resources) that the S-GW1 maintains in connection with the UE1, on timeout of the timer whose operation was started at the step S6 of FIG. 11.

<Third Stage>

FIG. 12 is a sequence diagram showing the operation of a third stage in case a signal has arrived in the second stage from the PDN such as IMS. The following describes respective stages.

In a step 1 of FIG. 12, a notification from the IMSI, indicating the incoming of voice services to the UE1, arrives at the G-SW1.

In a step S2 of FIG. 12, the G-SW1 stores the information that the UE1 is in an unregistered state due to the restarting of the MME1. Hence, the G-SW1 sends a downlink data notification (Downlink Data Notification), inclusive of the IMSI and the previously registered TA List, to the MME1, to inform the incoming of voice services (packet data).

If, in a step S3 of FIG. 12, the UE1, having the IMSI that has been notified, is not attached, the MME 1 performs paging of the UE1 for the received TA List, using the IMSI. However, there is such a case wherein, in carrying out the step S3, the UE1 has already selected another S-GW and has attached to the MME1. In this case, to prompt the S-GW1 to release the entirety of the bearers relevant to the UE1, the MME1 returns a downlink data notification acknowledge (Downlink Data Notification Acknowledge) response indicating the cause that the UE1 has already re-attached.

In a step 4 of FIG. 12, the UE1 performs the attachment operation on receipt of the paging employing the IMSI.

The attach operation of the UE in the step 4 of FIG. 12 is well-known to those skilled in the art and, not directly relevant to the present invention. Hence, explanation of the detailed configuration is dispensed with.

When the S-GW detects the restarting of the MME, if the tunnel (GTP-U) on the S1-U interface between the eNodeB and the S-GW is active, the S-GW releases the tunnel.

<Exemplary Embodiment 2>

As an exemplary embodiment 2 of the present invention, the following describes the operation at the time of SGSN restarting in the network configuration of FIG. 7. Basically, the operation of the exemplary embodiment 2 is equivalent to the operation at the time of restarting of MME in the exemplary embodiment 1. In the example of FIG. 7, 2G/3G is accommodated. Specifically, the eNodeB 102 and the MME 103 of FIG. 6 are replaced by a 2G/3G radio control apparatus (nodeB and RNC) 110 and an SGSN 111. An interface between the 2G/3G radio control apparatus (NodeB and RNC) 110 and the SGSN 111 is Iu, an interface between the 2G/3G radio control apparatus (NodeB and RNC) 110 and the S-GW 104 is S12, an interface between the SGSN and the S-GW is S4 and an interface between the SGSN 111 and the HSS 106 is an S6d/Gr.

The operation of the present exemplary embodiment may be summarized to have three separate stages.

<First Stage>

FIG. 13 is a sequence diagram showing a stage of registering the location registration area information of the UE in the S-GW1, as a first stage. The following describes respective steps.

In a step S1 of FIG. 13, the UE1 sends a location registration request (Attach Request/Routing Area Update Request) to the SGSN1. The Routing Area Update Request is a location registration update request to the SGSN.

In a step S2 of FIG. 13, the SGSN1 newly assigns the location registration area information (RAI) to the UE1.

In a step 3 of FIG. 12, the SGSN1 notifies the S-GW1 of the RAI of the UE1. The S-GW1 maintains the RAI notified as the registration information of the UE1.

The location registration operation of FIG. 12 is known per se among those skilled in the art and is not directly relevant to the subject-matter of the present invention. Hence, the operation is not explained in detail.

<Second Stage>

FIG. 14 is a sequence diagram for the stage of maintaining a bearer, as a second stage. The following describes respective steps.

In a step S1 of FIG. 14, the UE1 has already attached to the SGSN1, and a various types of bearers have been set up using the S-GW1 and P-GW1.

In a step 2 of FIG. 14, the processing of restarting occurs in the SGSN1. The registration information of the UE1 attached is erased.

In a step 3 of FIG. 14, the S-GW1 detects the restarting at SGSN1 by processing, such as a health check, by GTP Echo processing.

In a step S4 of FIG. 14, the S-GW1 recognizes the entirety of the mobile stations UE (it is confirmed that the UE1 is accommodated in SGSN1).

In case the present invention is applied to the entirety of services, all bearers are maintained in a step 5 of FIG. 14.

In steps 6 and 7 of FIG. 14, bearers are not maintained for the entirety of the services, as is done in the step 5 of FIG. 11. Instead, just a bearer relating to a specific service (IMS service, providing e.g., voice services, in the following example) is maintained.

After step S4 of FIG. 14 of confirming that the UE1 is accommodated in SGSN1, the S-GW1 confirms, in a step 6 of FIG. 14, whether or not there is the IMS signaling bearer among the bearers held by the UE1. The IMS signaling bearer is a bearer used for IMS signaling. In determining whether or not a bearer in question is the IMS signaling bearer, the value of a QCI (QoS Class Identifier), which is one of the control elements owned by each hearer, for example, may be used. If the QoS value is '5', for example, a hearer in question is determined to be the bearer for IMS signaling (IMS signaling) in accordance with Table 6.1.7 of Non-Patent Document 1 (3PP TS23.203). The hearer in question may thus be determined to be a control bearer used for providing voice services. If there is such IMS signaling hearer, the S-GW1 maintains just such bearer, and locally releases (removes) other bearers in accordance with the operation of Non-Patent Document 1 (3GPP TS23.007).

In case the IMS signaling bearer is maintained, the operation of a timer, which on timeout releases the bearer, is started in order to take account of the case where the UE1 has already attached to another S-GW1. This timer is necessary to prevent failing to release bearers that the S-GW1 maintains.

In case, in the above timer, the time equivalent to the time of a periodic location registration timer included in the UE1 is set, the S-GW1 may wait for incoming of voice services for a necessary minimum time corresponding to the time of the next periodic location registration request from the UE1. At this time, the fact that the UE1 has not been registered in the SGSN1 is stored in the S-GW1.

In a step S7 of FIG. 14, the SGSN1 is in such a state that the UE1 has not been registered and that only the IMS control bearer is maintained in the S-GW1 and in the P-GW1.

In case thereafter the third stage shown in FIG. 15 is not executed, the S-GW1 removes the entirety of the bearers maintained in connection with the UE1 (IMS control bearer resources) at a timeout time point of the timer whose operation started in the step 6 of FIG. 14.

<Third Stage>

FIG. 15 is a sequence diagram for illustrating the operation of a third stage in case of an incoming from PDN, such as IMS.

In a step S1 of FIG. 15, incoming notification of voice services from IMS1 to the UE1 gets to the S-GW1.

In a step S2 of FIG. 15, the S-GW1 sends the IMSI and the downlink data notification (Downlink Data Notification) inclusive of IMSI and RAI that have been registered in advance to the MME to inform the incoming of voice services (packet data). It is because the S-GW1 stores that the UE1 is in a non-registered state because of restarting of the SGSN1.

In case the UE1 that has the notified IMSI, has not attached, the SGSN1 in a step S3 in FIG. 15 performs paging of the UE1, for RAI received, using the IMSI. However, there is such a case wherein, in carrying out the step S3 of FIG. 15, the UE1 has already selected another S-GW and has attached to the SGSN1. In this case, to prompt the S-GW1 to release the entirety of the bearers relevant to the UE1, the SGSN1 sends back to the S-GW1 a downlink data notification acknowledge (Downlink Data Notification Acknowledge) response indicating the cause that the UE1 has already re-attached.

In a step 4 of FIG. 15, the UE1 that has received the paging employing the IMSI performs an attachment operation. The attachment operation of the UE of the step S4 of FIG. 15 is known per se among those skilled in the art and is not directly relevant to the subject-matter of the present invention. Hence, its detailed configuration is omitted.

<Exemplary Embodiment 3>

As an exemplary embodiment 3 of the present invention, the following describes the operation in case of employing an ISR function (LTE/3G location registration omitting function) under the network configuration of FIG. 8. In ISR, the UE registers its location in both the MME and the SGSN. In case of switching a radio access system between LTE and 2G/3G, UE location registration is omitted as long as there is no change in the previously registered location registration area in LTE and that in 2G/3G. FIG. 8 shows a packet communication network configuration accommodating LTE and 2G/3G. This configuration corresponds to the configuration of FIG. 1 added by a 2G/3G radio control apparatus 110 and an SGSN 111 to be connected to the UE 101. The MME 103 is connected to the SGSN 111 via an S3 interface, while the MME 103 and the SGSN 111 are connected to the HSS 106 via an S6a interface and an S6d/Gr interface. The S-GW 104 is connected to the SGSN 111 and to the MME 103 via an S4 interface and via an S11 interface.

<First Stage>

The processing of location registration for the UE1 from 2G/3G, as a first stage, is shown in FIG. 13. FIG. 10 may apply as regards the processing of location registration from LTE. By these two operations, the S-GW1 maintains RAI and TA List as the location registration area information. The processing of location registration during the ISR operation is known per se among those skilled in the art and is not directly relevant to the subject-matter of the present invention. Hence, its detailed configuration is omitted.

<Second Stage>

FIG. **16** is an example of a sequence as an operation in case of restarting of the MME**1** of FIG. **8**. FIG. **17** shows an example of a sequence as an operation in case of restarting of the SGSN**1** of FIG. **8**

In a step **1** of FIG. **16**, the UE**1** has its location registered in the MME**1**, and a various types of bearers have been established using the S-GW**1** and the P-GW**1**.

In a step **2** of FIG. **16**, restarting occurs in the MME**1**, so that the registration information of the UE**1** in the MME**1** is erased.

In a step **3** of FIG. **16**, the S-GW**1** detects the restarting of the MME**1** from processing, such as a health check by the GTP Echo processing.

In a step **4** of FIG. **16**, the S-GW**1** does not perform releasing of hearers because the S-GW**1** knows that the UE**1** attached to the MME**1** has been registered using the SGSN**1** and the ISR function. At this time, the fact that the UE**1** is not registered in the MME**1** is stored in an internal memory of the S-GW**1**. However, in case the SGSN**1** has already been restarted, the processing according to the present invention (processing of maintaining the bearer relevant to the UE**1**) is carried out as is the processing of FIG. **11**.

The following describes the operation in case the SGSN**1** of FIG. **8** has restarted.

In a step **1** of FIG. **17**, the UE**1** has its location registered in SGSN**1**, and a various types of bearers have already been set up using the S-GW**1** and the P-GW**1**.

In a step **3** of FIG. **17**, the processing of restarting, for example, occurs in the SGSN**1**, and the registration information of the UE**1**, which has its location registered, is erased.

In a step **3** of FIG. **17**, the S-GW**1** detects the restarting of the SGSN**1** from processing such as a health check the by GTP Echo processing.

In a step **4** of FIG. **17**, the S-GW**1** does not perform bearer releasing because the S-GW**1** knows that the UE**1** attached to the MME**1** has been registered using the MME**1** and the ISR function. The non-registration status of the UE**1** in the SGSN**1** is stored in the internal memory of the S-GW**1**. However, if the MME**1** has already restarted, the processing according to the present invention (processing of maintaining the bearer relevant to the UE**1**) is carried out as with the processing of FIG. **14**.

<Third Stage>

FIG. **18** is a diagram showing an example of a sequence of the operation in case there is an incoming from the PDN under a condition that the MME**1** of FIG. **8** has restarted, as a third stage. FIG. **19** is a diagram showing an example of a sequence of the operation in case there is an incoming from the PDN under a condition that the SGSN**1** of FIG. **8** is restarted. FIG. **20** is a diagram showing an example of a sequence of the operation in case there is the incoming from the PDN under a condition that both the MME**1** and the SGSN**1** of FIG. **8** are restarted.

In case there is an incoming from the PDN under a condition the MME**1** of FIG. **8** is restarted, incoming notification of communication services from the PDN**1** to the UE**1** gets to the S-GW**1** in a step **1** of FIG. **18**.

In a step **2** of FIG. **18**, the S-GW**1** sends a normal downlink data notification (Downlink Data Notification) to the SGSN**1** to inform the arrival of the incoming of voice services (packet data).

In a step **3** of FIG. **18**, the S-GW**1** sends a downlink data notification (Downlink Data Notification), inclusive of the IMSI and the pre-registered TA List, to the MME**1** to inform the incoming of voice services (packet data). It is because the S-GW**1** stores the non-registered state of the UE**1** on account of the restarting of the MME**1**.

In a step **4** of FIG. **18**, the SGSN**1** performs normal paging (paging of the mobile station responsive to the incoming).

In a step **5** of FIG. **18**, in case the UE**1** having the IMSI according to the notification is not attached, the MME**1** performs paging of the UE**1**, using the IMSI, by referring to the TA List received.

In a step **6** of FIG. **18**, paging employing the IMSI is received at LTE, the UE**1** performs an attachment operation.

The following describes a case wherein an incoming from the PDN is performed under a condition the SGSN has restarted.

In a step **1** of FIG. **19**, incoming notification of communication services from the PDN**1** to the UE**1** gets to the S-GW**1**.

In a step **2** of FIG. **19**, the S-GW**1** sends a normal downlink data notification (Downlink Data Notification) to the MME**1** to inform the incoming of voice services (packet data).

In a step **3** of FIG. **19**, the S-GW**1** sends a downlink data notification (Downlink Data Notification), inclusive of the IMSI and the pre-registered RAI, to the SGSM**1**, to inform the incoming of voice services (packet data). It is because the S-GW**1** stores the non-registered state of the UE**1** on account of the restarting of the MME**1**.

In a step **4** of FIG. **18**, the SGSN**1** performs normal paging.

In a step **5** of FIG. **18**, in case the UE**1** having the IMSI according to the notification has not attached, the SGSM**1** performs the paging of the UE**1**, using the IMSI, by referring to the RAI received.

In a step **6** of FIG. **19**, in case the paging employing the IMSI is received in 2G/3G, the UE**1** performs an attachment operation.

The following describes a case wherein an incoming from the PDN is performed under a condition both the MME and the SGSN have restarted.

In a step **1** of FIG. **20**, incoming notification of communication services from the PDN**1** to the UE**1** gets to the S-GW**1**.

In a step **2** of FIG. **20**, the S-GW**1** sends a downlink data notification (Downlink Data Notification), inclusive of the IMSI and the pre-registered TA List, to the MME**1** to inform the incoming of voice services (packet data). It is because the S-GW**1** stores the non-registered state of the UE**1** on account of the restarting of the MME**1**.

In a step **3** of FIG. **20**, the S-GW**1** sends a downlink data notification, inclusive of the IMSI and the pre-registered TA List, to the SGSN**1**, to inform the incoming of voice services (packet data). It is because the S-GW**1** stores the non-registered state of the UE**1** which is due to the restarting of the MME**1**.

In a step **4** of FIG. **20**, in case the UE**1** having the IMSI according to the notification is not attached, the MME**1** performs paging of the UE**1**, using the IMSI, by referring to the TA List received.

In a step **5** of FIG. **20**, in case the UE**1** having the IMSI according to the notification is not attached, the SGSN**1** performs paging of the UE**1**, using the IMSI, by referring to the RAI received.

In a step **6** of FIG. **20**, when receiving the paging employing the IMSI, the UE**1** performs an attachment operation.

The attachment operation of the UE of the step S**6** of FIGS. **11**, **12** and **13** is known per se among those skilled in the art and is not directly relevant to the subject-matter of the present invention. Hence, the detail configuration is omitted.

<Exemplary Embodiment 4>

FIG. **9** is a diagram showing a network configuration according to a fourth exemplary embodiment according to the present invention. In FIG. **9**, there is shown a CSFB (CS

Fallback) architecture. Referring to FIG. **9**, the network includes the UE **101**, a base station (eNodeB) **102**, an MME **103**, an HSS **106**, an MSC/VLR **112**, a CS network **113** and a G-MSC (gateway mobile switch center) **114**. The following describes the operation of voice incoming from the G-MSC **114** as an originating source to the UE **101** with reference to FIG. **9**.

A signal notifying the incoming is sent from the G-MSC **114** as an originating source to the MSC/VLR **112** via the CS network **113**. The MSC/VLR **112** identifies the corresponding MME **103** from the incoming information to send a paging request message (Paging-Request-Message) to the MME **103**. The MME **103** sends a paging signal to the UEs that reside in the serving area. This paging signal includes information indicating that the paging is for CS services. The UE **101** recognizes this information, that is, the information that the paging is that for CS services, and sends a CS service request signal to the MME **103**. The MME **103** sends a handover command to the UE**1**. The UE **101** performs handover, while switching to 3G. The UE **101**, which has switched to 3G, sends a paging response to the MSC/VLR **112**, as a result of which the voice services at the mobile station to the incoming voice are started. The following describes the operation when the MME restarts.

The operation according to the present invention may be summarized to have three separate stages.

<First Stage>

FIG. **21** is a sequence diagram showing, as a first stage, the stage of registering location registration area information of the UE. The following describes respective steps.

In a step **1** of FIG. **21**, the UE**1** makes a location registration request for CSFB (Attach Request, TAU Request and so forth) to the MME**1**.

In a step **2** of FIG. **21**, the MME**1** newly assigns (delivers) the location registration area information (TA List) to the UE**1**.

In a step **3** of FIG. **21**, the MME**1** notifies the MSC**1** of the TAU List of the UE**1**. The MSC**1** maintains the TAU List, notified from the MME**1**, as the registration information of the UE**1**.

The location registration operation of FIG. **21** is known per se among those skilled in the art and is not directly relevant to the subject-matter of the present invention. Hence, the detailed configuration is omitted.

<Second Stage>

FIG. **22** is a sequence diagram showing, as a second stage, the stage of maintaining a bearer. The following describes respective steps.

In a step **1** of FIG. **22**, the UE**1** has already attached to the MME**1**.

In a step **2** of FIG. **22**, restarting occurs in the MME**1** and the registration information of the UE**1** is erased.

In a step **3** of FIG. **22**, the MSC**1** detects the restarting of the MME**1** from processing such as a health check by SCTP.

In a step **4** of FIG. **22**, the MSC**1** recognizes the entirety of the mobile stations UE attached to the MME**1** (it is recognized that the UE**1** is accommodated in MME**1**). The above is the second stage.

<Third Stage>

FIG. **23** depicts an example sequence diagram showing, as a third stage, an operation sequence for the case of incoming (voice incoming or SMS, for example) via a CS domain. The following describes respective steps.

In a step **1** of FIG. **23**, an incoming notification to the UE**1** arrives at the MSC**1** by e.g., the G-MSC.

In a step **2** of FIG. **23**, the MSC**1** sends a paging request message inclusive of IMSI and pre-registered TA List (SGsAP-PAGING-REQUEST message) to the MME**1** to notify the MME**1** of the incoming. It is because the MSC**1** stores the non-registered state of the UE**1** brought about by restarting of the MME**1**.

In a step **3** of FIG. **23**, in case the UE**1** having the IMSI notified thereto has not attached, the MME**1** performs a paging of the UE**1**, using the IMSI, for the TA List received.

However, there is such a case wherein, in carrying out the step S**3** of FIG. **23**, the UE**1** has already selected another MSC and has attached to the MME**1**.

In this case, to prompt the MSC**1** to release the entirety of the bearers relevant to the UE**1**, the MME**1** sends back to the MSC**1** a paging reject message (SGsAP-PAGING-REJECT message) indicating the cause that the UE**1** has already re-attached.

In a step **4** of FIG. **23**, the UE**1**, which has received the paging that uses the IMSI, performs an attachment operation. The attachment operation of the UE in the step **4** of FIG. **23** is known per se among those skilled in the art and is not directly relevant to the subject-matter of the present invention. Hence, the configuration is omitted.

In the drawings of the above described exemplary embodiment, only one (P-GW**1**) is shown as the P-GW for simplicity of explanation. However, a plurality of P-GWs, such as P-GW**2**, P-GW**3** or P-GWN, may be used in a similar manner.

Another one of modes of the present invention will now be explained with reference to FIG. **24**, which supplements FIG. **10**, for example, and shows subscriber data re-installation by network triggered service request. It is noted that the eNodeB is omitted in FIG. **24**.

S**1**) The MME sends the latest TA-list to a relevant S-GW. That the MME informs the latest TA-list on a per UE basis to one or more S-GWs in every occurrence of mobility events. This information (TA list) is important in case of MME failure because paging of the IMSI for the coverage of the MME in its entirety may thereby be avoided. Since larger numbers of eNodeBs are accommodated in one MME, the load in the EPS system may become tremendously severe if paging is to be performed for the entire coverage.

S**2**) The MME performs restarting.

S**3**) With a restart counter increased by one, a GTP Echo message (GTP-V2 Echo response message) is sent to the entirety of the relevant S-GWs.

S**4**) The relevant S-GW detects MME failure by this GTP echo mechanism. The S-GW is able to maintain all or selected bearers, IMSI and the TA list. An operator is able to select a bearer based on top-rank services (IMS) (service on top (IMS)), as a result of which the bearer maintained may be selected only for important services. For other (selected) bearers, the current MME restarting mechanism is applied. S-GW is to maintain hearer resources, IMSI and the TA list, the S-GW starts a timer that controls a time interval for maintaining hearer resources, for example. On timeout of the timer, the hearer resources maintained are removed. This alternative is needed for such case in which, when the UE re-attaches to a network, the S-GW in question is not selected. That is, on timeout of the timer of the S-GW in question, the above mentioned bearer resources maintained, for example, S5/S8 bearers, which are specific bearers maintained, are removed on the assumption that the UE has re-attached to the network via a S-GW different from the S-GW in question.

S**5**) DL data arrives at the P-GW from an external network (PDN).

S**6**) The S-GW acquires the DL data from the P-GW.

S7) The S-GW sends a downlink data notification message inclusive of the IMSI and the TA list (DL data notification (IMSI, TA list)) to the MME.

S8) The MME starts the IMSI page ((Page (IMSI) to TAs specific in TA list) for all of TAs of the TA list received from S-GW.

S9) On receiving the IMSI page, the UE1 starts the attach (ATTACH) procedure.

S10) On receiving the attach (ATTACH) request from the UE, the MME sends a location information update request to the HSS.

S11) The HSS sends location information update acknowledge to the MME.

S12) The MME sends the ATTACH acceptance to the UE via eNodeB.

In case of detecting the restart of the MME, the S-GW maintains the hearer, IMSI or the TA list. In this manner, it is possible to instantaneously recover communication services after restart of the MME and after arrival of the DL data at the UE from the PDN side.

In a mode of the present invention, in case only the selected hearer is to be maintained, it is possible to suppress consumption of S-GW resources. In addition, by selecting and maintaining bearers for important services, communication services may instantaneously be restored for services of higher rank of importance, such as voice communication, on arrival of an incoming to the mobile station, after the restarting of the MME.

In another mode of the present invention, in case a bearer is to be maintained by itself or together with the IMSI and the TA list, the time interval of the maintenance is managed by a timer. On timeout of the timer, the bearer, IMSI and the TA list maintained are released. By so doing, in case, after restart of the MME, the mobile station moves and attaches to a G-SW different from the S-GW that maintains the bearer, it is possible to prevent the S-GW that maintains the bearer from maintaining the bearer longer than is necessary.

According to the present invention, described above, the following effects may be realized.

UE's communication services may be improved in availability by adding packet incoming as a re-registration trigger of a UE registered in the MME/SGSN in which restarting occurred.

In case the present invention is applied to all services, incoming of the entirety of the packets may be used as a trigger for restoring the UE to the network. It may however be thought that many resources on the S-GW side are used, and that location registration events may become concentrated. The S-GW1 is able to maintain the TA list and to perform the Paging processing by using the TA list. However, if it is not possible for the S-GW to receive the TA list from the MME1, the paging may be performed for the whole area supervised by the MME1. In this case, many of the radio network side resources would be consumed.

According to the present invention, the S-GW1 is able to maintain the RAI and to perform the Paging processing by using the RAI. If it is not possible for the S-GW1 to receive the RAI from the SGSN1, the paging may be performed for the whole area supervised by the SGSN. In this case, many of the radio network side resources would be consumed.

The disclosures of the aforementioned Non-Patent Documents are incorporated by reference herein. The particular exemplary embodiments or examples may be modified or adjusted within the gamut of the entire disclosure of the present invention, inclusive of claims, based on the fundamental technical concept of the invention. Further, a various types of combinations or selection of elements disclosed herein may be made within the framework of the claims. That is, the present invention may cover a wide variety of modifications or corrections that may occur to those skilled in the art in accordance with the entire disclosure of the present invention, inclusive of claim and the technical concept of the present invention.

What is claimed is:

1. A mobile terminal used in a mobile communication network that includes a mobility management node (MMN) serving the mobile terminal, said MMN comprising one of a mobility management entity (MME) and a serving GPRS support node (SGSN), and a serving gateway (S-GW), the mobile terminal comprising:

a receiver that receives a paging from the mobile communication network based on an arrival of an incoming call destined for the mobile terminal at the mobile communication network with the serving gateway; and

a transmitter that in response to the paging, re-attaches to the mobile communication network,

wherein the serving gateway, starts a timer upon restarting of the MMN, maintains specific a S5/S8 bearer related to the mobile terminal for a preset time period prescribed by the timer, deletes all bearers except the maintained bearer bearer before expiration of the timer and deletes the maintained bearer the expiration of the timer.

2. A method for registration of a mobile terminal in a mobile communication network that includes a mobility management node, said node comprising one of a mobility management entity (MME) and a serving GPRS support node (SGSN), and a serving gateway (S-GW), the method comprising:

receiving, by the mobile terminal, a paging from the mobile communication network, upon an arrival of an incoming call destined for the mobile terminal at the mobile communication network with the serving gateway; and

re-attaching to the mobile communication network, by the mobile terminal, in response to receipt of the paging,

wherein the serving gateway, starts a timer upon restarting of the MMN, maintains specific a S5/S8 bearer related to the mobile terminal for a preset time period prescribed by the timer, deletes all bearers except the maintained bearer before expiration of timer and deletes the maintained bearer the expiration of the timer.

3. The mobile terminal according to claim **1**, wherein the S-GW detects the restarting of the MMN from a processing.

4. The mobile terminal according to claim **3**, wherein said processing comprises a GTP (GPRS Tunneling Protocol) Echo processing.

5. The mobile terminal according to claim **1**, wherein the S-GW starts an operation of said timer.

6. The mobile terminal according to claim **5**, wherein said timer controls a time of maintaining the specific S5/S8 bearer by the S-GW.

7. The mobile terminal according to claim **1**, wherein if the S-GW detects restarting of the MMN , and a tunnel (GTP-U) on an interface between an eNodeB (evolved NodeB) and the S-GW is active, then the S-GW releases said tunnel.

8. The mobile terminal according to claim **1**, wherein, if the mobile terminal has selected another S-GW and has attached to the MMN, then the MMN returns a Downlink Data Notification Acknowledge response indicating that the mobile terminal has already re-attached.

9. The mobile terminal according to claim **8**, wherein said Downlink Data Notification Acknowledge prompts said S-GW to release one or more bearers associated with the mobile terminal.

10. The mobile terminal according to claim 1, wherein, upon the mobile terminal selecting a different S-GW, the S-GW releases one or more bearers associated with the mobile terminal.

11. The mobile terminal according to claim 1, wherein said specific S5/S8 bearer comprises a bearer used for IP Multimedia Subsystem (IMS) signaling.

12. The mobile terminal according to claim 11, wherein the S-GW confirms whether there is a bearer providing the IMS signaling from among the bearers owned by the mobile terminal.

13. The mobile terminal according to claim 1, wherein the S-GW receives a notification from an IMSI (International Mobile-Station Subscription Identifier), indicating an incoming voice service to the mobile terminal.

14. The mobile terminal according to claim 1, wherein the MMN , upon detecting that an attach procedure is completed in the mobile terminal, sends back to the serving gateway a Downlink Data Notification Acknowledge signal.

15. The mobile terminal according to claim 14, wherein said Downlink Data Notification Acknowledge signal comprises a signal indicating a cause of an attachment of the mobile terminal.

16. A mobile terminal (UE) used in a mobile communication network that includes a mobility management node (MMN), said MMN comprising one of a mobility management entity (MME) and a serving GPRS support node (SGSN), and a serving gateway (S-GW), the mobile terminal comprising:

a receiver that receives a paging from the mobile communication network based on an arrival of an incoming call destined for the mobile terminal at the mobile communication network with the serving gateway; and

a transmitter that, in response to the paging, re-attaches to the mobile communication network,

wherein the serving gateway detects that the MMN has restarted after a cessation of service and, upon restarting of the MMN , maintains a specific S5/S8 bearer for a preset time period prescribed by a timer and deletes S5/S8 bearers other than the specific bearer within the preset time period,

wherein the serving gateway deletes the specific S5/S8 bearer on timeout of the timer,

wherein the serving gateway determines the specific S5/S8 bearer to be related to the mobile terminal and confirms the mobile terminal to be accommodated in the MME, and

wherein the specific S5/S8 bearer comprises a bearer carrying an Internet Protocol Multimedia Sub-system (IMS) signaling.

17. The mobile terminal according to claim 1, wherein the serving gateway determines the specific S5/S8 bearers to be related to the mobile terminal and confirms the mobile terminal to be accommodated in the MMN.

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